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SPECIAL STUDY OF MOBILITY IN THE MEKONG DELTA AREA OF SOUTH VIETNAM

Prepared for:

ADVANCED RESEARCH PROJECTS AGENCY AND
OFFICE OF NAVAL RESEARCH (CODE 493) WASHINGTON, D.C.

Contract No. Nonr-4194(00)
ARPA Order 574 (12 May 1964)
Program Code 4860

SOUTHERN CALIFORNIA LABORATORIES
of STANFORD RESEARCH INSTITUTE

SOUTH PASADENA, CALIFORNIA

*SRI

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152617

March 1965

Final Report

SPECIAL STUDY OF MOBILITY IN THE MEKONG DELTA AREA OF SOUTH VIETNAM

By: George Brinton, Kenneth Clare, and Irving Dow

SRI Project No. ISU-4552

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PREFACE

This study was conducted for the Advanced Research Projects Agency under ARPA Order No. 574 (12 May 1964) to the Office of Naval Research, the contracting agency. Commander Robert L. Dise (USN) of ARPA's Remote Area Conflict Project (Project AGILE) was Project Officer. This study for ARPA was conducted under contract to ONR concurrently with a broader study of counterinsurgency and unconventional warfare undertaken for ONR's Advanced Warfare Systems Division (Code 493) under the direction of Mr. Irwin Schiff, ONR's Project Officer.

The research was conducted by the Southern California Laboratories of Stanford Research Institute. Dr. Irving Dow was project manager, and Dr. George Brinton was project leader. A major contribution was made by Dr. Kenneth Clare. Dr. John Davis, Herbert Bricker, Elinor Simpson, and Roberta Lloyd also contributed to the study. Mr. Irwin Schiff of ONR (Code 493) and Major John Flynn, USMC (Landing Force Development Center) accompanied the Institute's field team on its trip to South Vietnam and assisted greatly in conduct of the field work.

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I INTRODUCTION

One of the basic missions of the Advanced Research Projects Agency is to conduct research and development in support of local forces engaged in conflict in remote areas of the world. For several years ARPA Project AGILE has been supporting research and development activities specifically intended to improve the operational capabilities and effectiveness of South Vietnamese forces. A significant amount of this R&D activity has been concerned with questions of mobility--particularly air mobility--and with specific problems of employment of armored personnel carriers in South Vietnam. The ARPA has recognized that surface movement is a particular problem in the Mekong Delta area of South Vietnam. Because of the dense networks of waterways and great expanses of rice paddy, marsh, and swamp and the attendant difficulties in moving expeditiously over such surfaces, even for relatively short distances, tactical and combat support operations against the Viet Cong are frequently frustrated.

In May 1964, ARPA requested the Institute to undertake an intensive assessment of the possibilities of improving the mobility of forces presently operating in the Mekong Delta area. As indicated in the preface, this study for ARPA was conducted concurrently with a broader-scope study of counterinsurgency and unconventional warfare undertaken for the Office of Naval Research (Code 493). The ONR study is particularly concerned with problems of counterinsurgency in geographic situations in which extensive use of restricted or inland waterways might be of special importance. South Vietnam presents such a case, and there is therefore a close relationship between the two studies, even though study objectives are somewhat different. This present report is concerned solely with the results of the Institute study for ARPA on the problems of mobility in the Mekong Delta area. The results of the ONR study are being presented in an entirely separate report.

At the outset of this ARPA study it was established that, because of the extensive networks of rivers and canals in the Delta, consideration would need to be given both to means of making better use of the waterways and to means of overcoming the obstacle these waterways pose to off-road movement by ground vehicles. One of the specific problems was therefore to assess the potential for using the waterways more extensively and more effectively than is being done in current operations against the Viet Cong. This problem thus involved consideration of both the needs for improved small craft (or other platforms for use on the waterways) and the concepts of operational employment for use of the waterways. A second major problem was to assess the feasibility of achieving significant improvements in mobility through use of new or improved off-road vehicle designs that could operate effectively over paddy and marsh land and also in crossing the streams, canals, ditches, paddy dikes, and other obstacles to expeditious surface movement by ground vehicles.

In the following paragraphs, the specific objective of the ARPA study of South Vietnam is described, and the general scope of the effort and the research approach are considered briefly.[1]

Objective

The overall objective of the research was to assess the possibilities of improving the mobility of forces in the Mekong Delta area of South Vietnam. The primary concern was for an assessment of possible means of achieving improvements in the immediate or very short time period rather than over a long period of time involving extensive research, development, and testing of new equipment. The objective and focus of the research are clearly indicated in the following, which is quoted from the original ARPA order:

> It is requested that you undertake an intensive analysis of operational problems in the Mekong Delta area in which an attempt will be made to identify techniques and equipments that could be adopted with very little delay to produce significant improvements in the mobility of forces now operating there. Of particular concern will be consideration of the types of platforms, including small craft, amphibians, GEMS, or other types of vehicles that could be made available to the operating forces on the basis of existing technology.

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1. The ARPA order specified that brief consideration should be given to possible problems of mobility in the East Pakistan area, including particularly the nature of environmental conditions there. As indicated in the order, this part of the research is to be covered in a separate report.

Scope and General Method of Approach

At the outset of the research, it was agreed that the study would best be structured as a three-phase research program extending over a period of five to six months.

The Phase I effort was initiated with a detailed study of the literature and an extensive program of field contacts with representatives of appropriate governmental agencies and industrial organizations in the United States to obtain pertinent information concerning (1) the design and performance characteristics of present and proposed small craft and ground vehicles (or new platform concepts) that might be considered for employment in the Delta, (2) conditions of the physical environment critical to the potential performance of particular craft and vehicles that might be employed in the Delta, and (3) the nature of military operations in South Vietnam, particularly in the Delta area.

Phase I also included the construction of an air photo mosaic of the entire Delta area and large-scale mosaics of several sample areas chosen to reflect conditions in different parts of the Delta. Additionally, a preliminary analysis was made of small craft and vehicle performance potentials in the Delta environment for purposes of identifying platform designs that should be considered further. Moreover, an important objective of Phase I was to identify in specific terms the information that would have to be obtained in the field in Vietnam. Thus, the planning for the field work in Vietnam was based on detailed study of materials available in the United States and on analysis of the nature of the informational needs that could be filled only through observations or discussions in Vietnam.

Phase II of the study was the field work in South Vietnam. Of particular concern in the field work was the development of information on (1) specific hydrographic and surface conditions on which details are not available in existing intelligence documents, (2) the performance currently being obtained and the operating difficulties being experienced in the use of specified vehicle and craft in the Delta area, (3) the level of mobility required and the need for improved mobility in various types of operations conducted by the Vietnamese, and (4) possible concepts of operations that might be formulated to meet different operational objectives if improved means of movement were available.

The six-man field team spent nearly a month in South Vietnam.[1] The entire Delta area (all of South Vietnam south of Saigon) was systematically overflown at an altitude of 2,500 to 3,000 feet to permit close aerial observation of waterway and surface conditions. Moreover, many opportunities were obtained to make aerial observations of ground conditions at very low altitudes during the course of numerous trips into various parts of the Delta for observation of military activities and discussions with U.S. advisors to Vietnamese operational units. Despite the restrictions imposed on freedom of movement because of security problems, limited on-the-ground observations of surface conditions were made in seven or eight Delta provinces during these visits to the field. Useful discussions were held in the field with U.S. advisors to Vietnamese Army units at various locations in the Delta, with advisors to the Vietnamese Navy River Assault Groups, with advisors to the Vietnamese Marine Corps, and with U.S. Army and USOM (United States Operations Mission) advisors to various province chiefs in the Delta. Also, guidance was obtained through discussions with personnel in J-2 and J-3 staffs of MAC-V and in the Navy Section of the MAAG. In addition, many extremely useful reports and back-up file information not available in the United States were found in the offices of the ARPA R&D Field Test Unit and ACTIV (Army Concept Team in Vietnam). The Ministry of Public Works was a most important source of information on conditions of the waterways.

At the conclusion of the field work in South Vietnam, one member of the project team went to Tokyo for discussions of mapping and the environmental studies with the Army Map Service (Far East). One member went to Bangkok for a week's work with members of ARPA's staff engaged in environmental and mobility studies. The other four team members went to Malaysia for two days of discussions at the British Jungle Warfare School north of Johore Bahru. Of particular interest in these latter discussions were the contrasts between the situation in Borneo and the operational concepts of the British and Malaysians on the one hand and the situation in South Vietnam and the problems of the United States and the Vietnamese on the other.

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1. The field team included Drs. George Brinton, economist and operations analyst; Kenneth Clare, economist and transportation specialist; John Davis, consulting hydrologist and civil engineer; and Irving Dow, marine engineer and geographer. Mr. Irwin Schiff, Project Officer from ONR, and Major John Flynn, USMC, also were working members of the project team.

Phase III of the study constituted detailed analyses of information developed in Phases I and II and assessment of various possible means of improving mobility in the Delta area of South Vietnam. In late December, near the end of this final phase of the research, an oral presentation of the basic findings of the study was made to ARPA and to ONR. A transcript of this presentation, together with illustrative materials, was subsequently submitted to ARPA and ONR.

The overall approach of study is reflected in the following listing of the major research tasks undertaken:

1. Description of the environmental situation in terms of factors critical to the performance of various existing and projected water craft and surface vehicles, including in particular the density of the waterway network; probable stream and canal depths; bank characteristics; and surface conditions, including the state of the ground, the occurrence of dikes and ditches, and the relative occurrence and distribution of rice paddy land, marsh areas, swamp and forests, and other particular features of the landscape in the Delta.

2. Analysis of the nature of Viet Cong activities and Vietnamese counterinsurgent operations (present and projected) and identification of the specific types of operations in which improved mobility is perhaps essential to effective military operation against the Viet Cong--thus identifying possible requirements or worthwhile opportunities for improvement in mobility.

3. Evaluation of the performance potentials of individual small craft and ground vehicles or platforms in relation to the specific environmental situations described and identification of water craft and vehicular design concepts or design modifications that would be particularly well suited to physical conditions in the Mekong Delta.

4. Analysis and selection of alternative platform designs (small craft, surface vehicles, GEM's) that would offer significant improvements in mobility as required for specified types of missions and concepts of operational employment.

5. Formulation of conclusions and recommendations as to specific small craft and vehicle designs that should be considered for adoption if the mobility of various types of forces operating in the Delta area is to be improved in the immediate time period.

The scope of the research did not include specification of the numbers of vehicles or craft required to provide particular types of operational capabilities. Neither did it include determination of the probable system costs nor a rigorous analysis of the operational effectiveness to be attained under alternative means of improving the mobility of specific types of forces. Rather, the research was concerned with analysis of environmental and operational problems relating to the requirements for mobility or improved mobility and with an assessment of the potential suitability of alternative means that might be considered to meet different types of operational requirements.

II CONCLUSIONS

This study has been concerned with the identification of techniques and equipments that could be adopted and made available in the immediate time period to produce significant improvements in the mobility of military forces in the Mekong Delta area of South Vietnam. The limitations on mobility imposed by the physical environment in the Delta area have been analyzed in detail. The types of activities in which improved mobility is probably essential to effective Vietnamese counterinsurgent operations have been identified. Alternative types of small craft and off-road vehicle designs have been assessed as to their potential suitability in providing improved mobility in specific types of situations and environments in the immediate time period.

The specific conclusions of this research are as follows:

1. The realization of a fundamental improvement in the mobility of forces in the Delta area will require the provision of more capability for expeditious off-road and off-canal movement. Roads and canals are highly vulnerable to ambush and are readily blocked or made unusable. Military operations should not be dependent on waterborne movement on other than the principal rivers.

2. Major improvements in capabilities for off-road and off-canal movement can be achieved by permanently deploying unarmored, tracked logistic-type amphibians at key locations in the Delta where they will be immediately available for use in personnel movements within local areas.

3. Effective employment of these vehicles will require that rigorous training and discipline be provided to achieve a primary dependence on off-road travel for local movements and thus to minimize the likelihood of ambush.

4. The planning and conduct of off-road movements to minimize water crossings (and the consequent delays) and to avoid ambush sites could be aided materially by making available large-scale photo mosaics to supplement available map coverage and to provide detailed terrain intelligence.

5. The M-116 tracked amphibian and the XM-571 (articulated body) tracked amphibian should be considered as prime candidates to meet this requirement for an off-road vehicle. Both have good mobility over adverse surface conditions and are in the inventory or can be made available in substantial numbers immediately. Additional M-113's (the armored personnel carriers presently in use in South Vietnam) could be employed to meet this potential requirement, but these vehicles have somewhat poorer mobility and are much more costly than would be the case with either the M-116 or the XM-571.

6. Decisions as to the possible procurement of large numbers of such vehicles as are specified above for introduction into South Vietnam must be based on a detailed assessment of the comparative costs and differences in potential effectiveness.

7. Capabilities of the River Assault Groups (RAG's) to provide for deployment of tactical units in operations along the major rivers should be improved. The effectiveness of the RAG's (and thus the mobility of the tactical units being supported) could be significantly enhanced with the provision of faster boats than are now available in-country. Faster craft of suitable designs could be provided in the immediate time period on the basis of existing technology.

8. Present slow-speed river patrol craft and sporadic patrol operations are ineffective in meeting the requirement for regular patrol and surveillance operations on the major rivers. The introduction of fast river patrol craft equipped with appropriate surveillance gear, together with the rigid enforcement of curfews, could greatly curtail or limit the freedom of Viet Cong movement into and within the Delta.

9. To implement pacification plans and to establish local security, it will be necessary to patrol and control the use of canals and smaller waterways within specified areas. The ARPA-developed Klong boat could be advantageously employed in such operations because of its shallow draft and good maneuverability. (The capabilities of this craft could be greatly enhanced by the development and use of silent or near-silent outboard motors.)

III CHARACTERIZATION OF THE PHYSICAL ENVIRONMENT

The purpose of this section of the report is to describe the characteristics of the physical environment that may critically influence the degree to which mobility can be improved in the Mekong Delta area of South Vietnam. For purposes of this study, the Mekong Delta area was taken to include nearly all of South Vietnam south of 11° north latitude. (Saigon is located at about 10°45' north latitude.) The only area south of 11° that was excluded from the study area is the hill country to the east of Saigon. These hills form the southern limit of the rugged, largely jungle-covered hill and mountain country that extends northward. The study area is therefore only the broad lowland plain, or Mekong Delta area, of the southern part of South Vietnam.

The Delta area includes large expanses of rice paddy, extensive marsh and swamp areas of various kinds, and dense networks of rivers and canals, all of which create difficult conditions or pose severe obstacles impeding the expeditious movement of military forces. It is the specific conditions that cause problems of movement or mobility in the different parts of the Delta that are of particular concern in this analysis. Essentially different environmental situations will be identified and distinguished in terms of the problems of movement, and the relative occurrence and geographic distribution of these different situations will be established.

As was indicated earlier, one of the objectives of this study was to assess the possibilities of making greater use of the waterways. There is therefore a fundamental need to consider the characteristics of the waterways as they influence the types of watercraft that could be employed and the concepts of employment that might be adopted. There is also a need to consider the characteristics of the waterways as they influence off-road vehicular movement or pose obstacles to such movement. In this section, then, attention is first devoted to the waterways as such, and consideration is then given to surface conditions in the Delta and to the problems of movement in the different types of environmental or topographical situations, such as paddy land, flooded forest, and so on.

Characteristics of the Waterways

The potential for greater utilization of the dense network of waterways, including major rivers and canals as well as lesser streams and man-made waterways, depends critically on such conditions as waterway depths, widths, curvatures, and currents and on the occurrence of such potential obstacles to navigation as low bridges, fish traps, barriers, or vegetation. Seasonal differences in waterway conditions are also significant and must be taken into consideration.

The extent to which accessibility to various parts of the Delta can be improved by placing dependence on waterways must be considered. In this respect it is essential to direct attention not only to the density of the network and the physical characteristics of the waterways as they influence the potential for greater use of watercraft in military movements but also to the likelihood of the Viet Cong's taking actions to deny the use of the waterways by government forces. The Viet Cong have developed considerable skills in countering the use of the waterways and in attacking military movements on the canals. The threats of mining and ambush are greatest in those situations where canal or stream banks are densely settled or covered with heavy vegetation. In much of the Delta, population settlements are in fact concentrated along the banks of canals and streams. The avoidance or countering of V.C. ambush tactics in such situations is made particularly difficult because of the dangers to the civilian populace. Therefore, conditions of the waterways, or along the waterways, that bear on the likelihood of successful V.C. attacks or ambush must also be considered.

In this discussion of the waterways, therefore, attention is given both to the physical conditions that would influence the feasibility of greater use of waterborne movements and to the specific characteristics of the environment that would influence design requirements for watercraft that potentially could be utilized to achieve improved mobility for various types of forces in the Delta.

General Hydrology

A dominant feature of the Delta landscape is the extensive network of interconnecting rivers, canals, and lesser waterways. Over much of this area, the Mekong and Bassac rivers, flowing southeastward across the Delta, have a controlling influence on the water levels of canals and on such other characteristics as current velocities and waterway depths and bottom conditions. The deltas of the Mekong and the Saigon merge with those of a number of the smaller rivers north of the Mekong to form a broad alluvial plain with only micro relief. These rivers have typically divided and subdivided in the lower reaches of the Delta to produce many large and small tidal streams and channels.

The floodwaters of the Mekong and the Bassac (and certain of the lesser rivers) annually inundate a vast area of the Delta. The area subject to general inundation during the flood season is shown on Map 1. The Bassac overflows its right bank in the upper Delta, and the waters spread over a large area, as indicated on the map. The floodwaters flow slowly overland and through the numerous major canals to the Gulf of Thailand (bounding the west coast of the Ca Mau Peninsula). The Mekong overflows its left bank and inundates much of the Delta north of the Mekong, including a great marsh area known as the Plain of Reeds. Drainage is very poor in this area, and much of the water stands until dissipated by evaporation. There is only limited outflow through the drainage canals and the rivers north of the Mekong. Thus, great expanses of terrain remain inundated or waterlogged for extended periods of time. Seaward of the area shown as subject to general inundation, additional large expanses of the Delta are subject to local flooding or inundation during the wet season and during periods of high tides.

Map 1 shows the structural outline of the network of navigable canals extending over the Delta. The characteristics of these canals will be considered in more detail after the following general discussions of the climatic situation and the influence of tides on waterways in the Delta.

Climate

Specific consideration should be given to the nature of the climate in the Delta area, since it has a fundamental influence on the characteristics of the waterways and on surface conditions throughout the study area. A tropical monsoonal climate characterizes the entire Delta area of South Vietnam, as may be seen in an examination of the climatological data in Table I. The table provides information on mean, maximum, and minimum rainfall and temperature, by months, for four stations. The locations of these meteorological stations are indicated on Map 1.

The climate is continuously hot throughout the year, but rainfall occurs principally during the months May through October. Thus, there is a distinct dry season. This is a major factor influencing waterway depths, state of the ground, and surface trafficability. Saigon receives about 78 inches of rainfall annually, 68 inches of which fall during the months May through October. Ca Mau in the southern part of the Delta receives almost 90 inches of rainfall annually under the same general seasonal pattern as is indicated for Saigon. While the season of heavy

Table I

COMPARISON OF MEAN AND ABSOLUTE MONTHLY TEMPERATURE AND PRECIPITATION AT SELECTED STATIONS

South Vietnam - Mekong Delta Area

Station[a]	Temperature/Precipitation												
	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Saigon													
Temperature (°F)													
Mean	78	80	82	84	82	81	80	81	80	80	79	78	80
Mean daily maximum	89	91	93	95	92	89	88	88	88	88	87	87	90
Mean daily minimum	70	71	74	76	76	75	75	75	74	74	73	71	74
Absolute daily maximum	98	102	103	104	102	100	94	95	96	94	95	97	104
Absolute daily minimum	57	61	64	68	70	59	67	69	69	68	64	57	57
Precipitation (inches)													
Mean	0.6	0.1	0.5	1.7	8.7	13.0	12.4	10.6	13.2	10.6	4.5	2.2	78.1
Maximum	4.4	0.4	5.1	7.0	22.1	20.6	23.4	19.7	20.0	23.7	11.3	6.3	107.0
Minimum	0.0	0.0	0.0	0.0	1.9	6.1	3.9	4.6	8.0	3.2	0.1	0.2	57.3
Maximum 24-hour	2.7	0.4	4.1	3.5	4.1	5.4	5.9	7.0	5.2	4.5	5.2	2.8	7.0
Mean number of days with $\geq$ 0.004 inch	2	1	2	5	17	22	23	21	22	20	11	7	153
Can Tho													
Temperature (°F)													
Mean	80	81	83	84	82	81	82	81	81	81	81	79	81
Mean daily maximum	86	88	91	93	91	89	87	87	86	86	86	85	88
Mean daily minimum	71	72	74	76	76	75	75	76	76	76	76	73	75
Absolute daily maximum	94	94	97	99	98	96	98	94	93	93	94	92	99
Absolute daily minimum	61	66	67	70	70	68	70	70	72	71	70	66	61
Precipitation (inches)													
Mean	0.4	0.1	0.5	1.7	6.6	7.2	8.9	6.7	10.9	9.8	6.6	2.0	61.4
Maximum	2.2	2.6	3.3	7.0	15.0	13.2	17.7	12.1	16.7	19.2	18.5	9.1	73.9
Minimum	0.0	0.0	0.0	0.0	1.2	2.7	5.8	1.9	4.4	5.4	9.8	0.0	49.3
Maximum 24-hour	1.9	2.2	1.6	4.4	3.7	3.7	5.0	3.0	3.3	3.6	7.8	4.0	7.8
Mean number of days with $\geq$ 0.004 inch	2	-	2	4	15	17	19	17	19	17	12	6	130
Ha Tien													
Temperature (°F)													
Mean	79	80	82	82	82	82	80	81	81	80	80	79	81
Mean daily maximum	86	87	87	88	88	87	85	86	85	85	85	85	86
Mean daily minimum	71	73	74	76	77	77	76	76	76	75	74	72	75
Absolute daily maximum	91	94	95	92	94	91	90	91	91	90	90	90	95
Absolute daily minimum	60	66	67	67	70	68	70	69	69	68	63	63	60
Precipitation (inches)													
Mean	0.5	0.6	1.9	5.1	9.1	9.3	12.4	10.9	9.7	9.5	5.1	1.9	76.0
Maximum	5.4	3.8	16.6	13.6	19.9	16.3	29.1	22.6	20.5	17.0	14.6	10.3	115.3
Minimum	0.0	0.0	0.0	0.0	1.8	2.0	3.3	1.6	1.3	1.0	0.0	0.0	42.1
Maximum 24-hour	2.2	1.5	9.2	3.9	4.1	7.1	7.3	6.8	4.4	4.3	5.1	3.5	9.2
Mean number of days with $\geq$ 0.004 inch	2	1	3	8	14	14	16	15	15	14	9	4	115
Ca Mau													
Temperature (°F)[b]													
Mean													
Mean daily maximum													
Mean daily minimum													
Absolute daily maximum													
Absolute daily minimum													
Precipitation (inches)													
Mean	0.6	0.4	1.1	4.3	10.9	11.1	12.5	11.6	13.7	12.1	6.9	4.7	89.8
Maximum	1.1	1.4	3.9	7.7	16.5	14.2	16.4	17.5	19.0	18.0	11.7	9.7	103.6
Minimum	0.0	0.0	0.0	1.6	2.6	6.7	8.5	7.2	10.2	5.8	2.6	0.9	77.2
Maximum 24-hour	0.8	1.1	3.6	2.6	3.6	3.0	3.3	4.1	3.4	3.8	5.0	5.0	5.0
Mean number of days with $\geq$ 0.004 inch	5	1	2	8	19	19	21	17	21	20	15	11	159

a. For general location of stations, see map showing hydrology of Delta area.

b. Detailed temperature data not available.

Source: Climate and Weather Section of the NIS.

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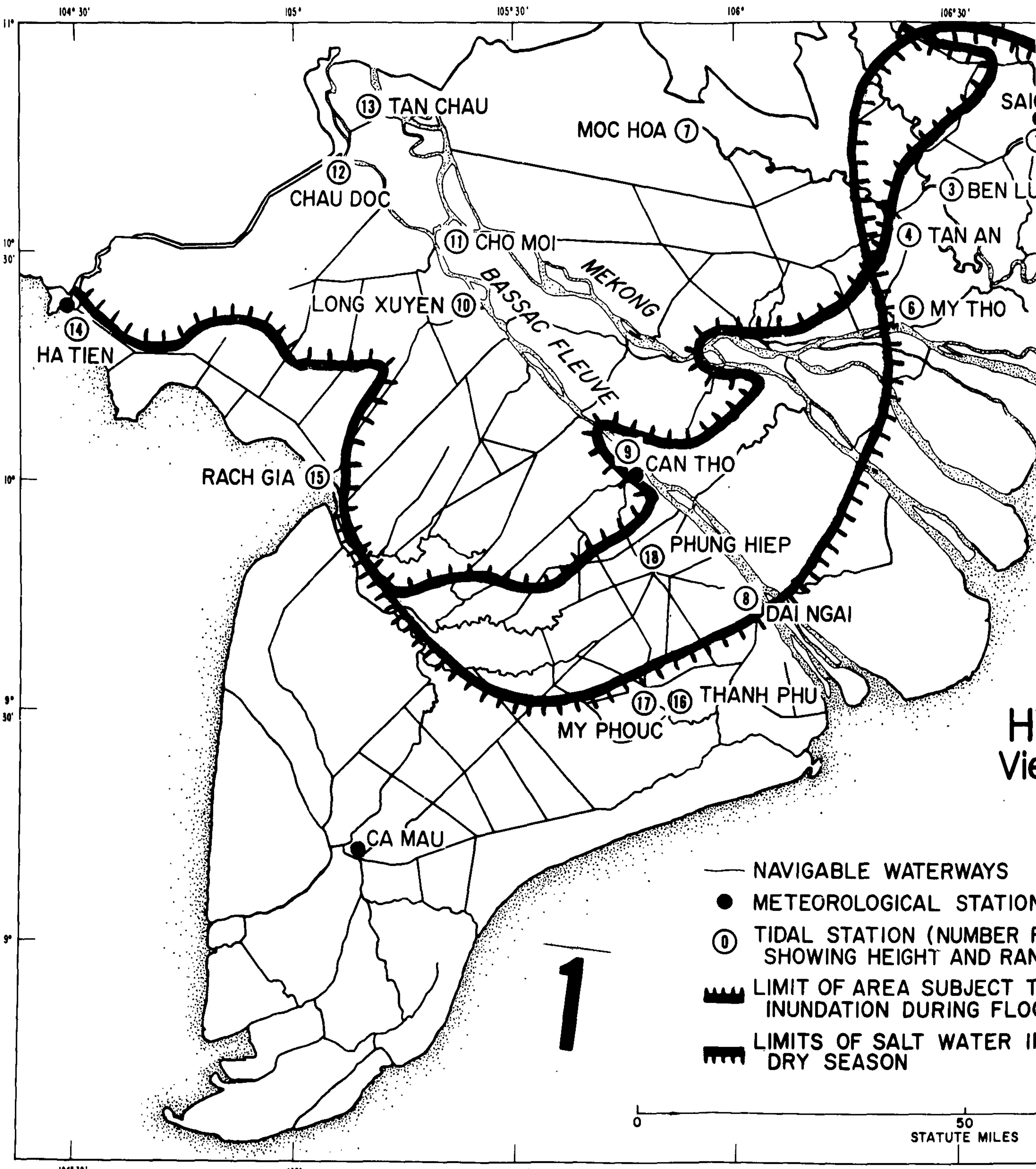

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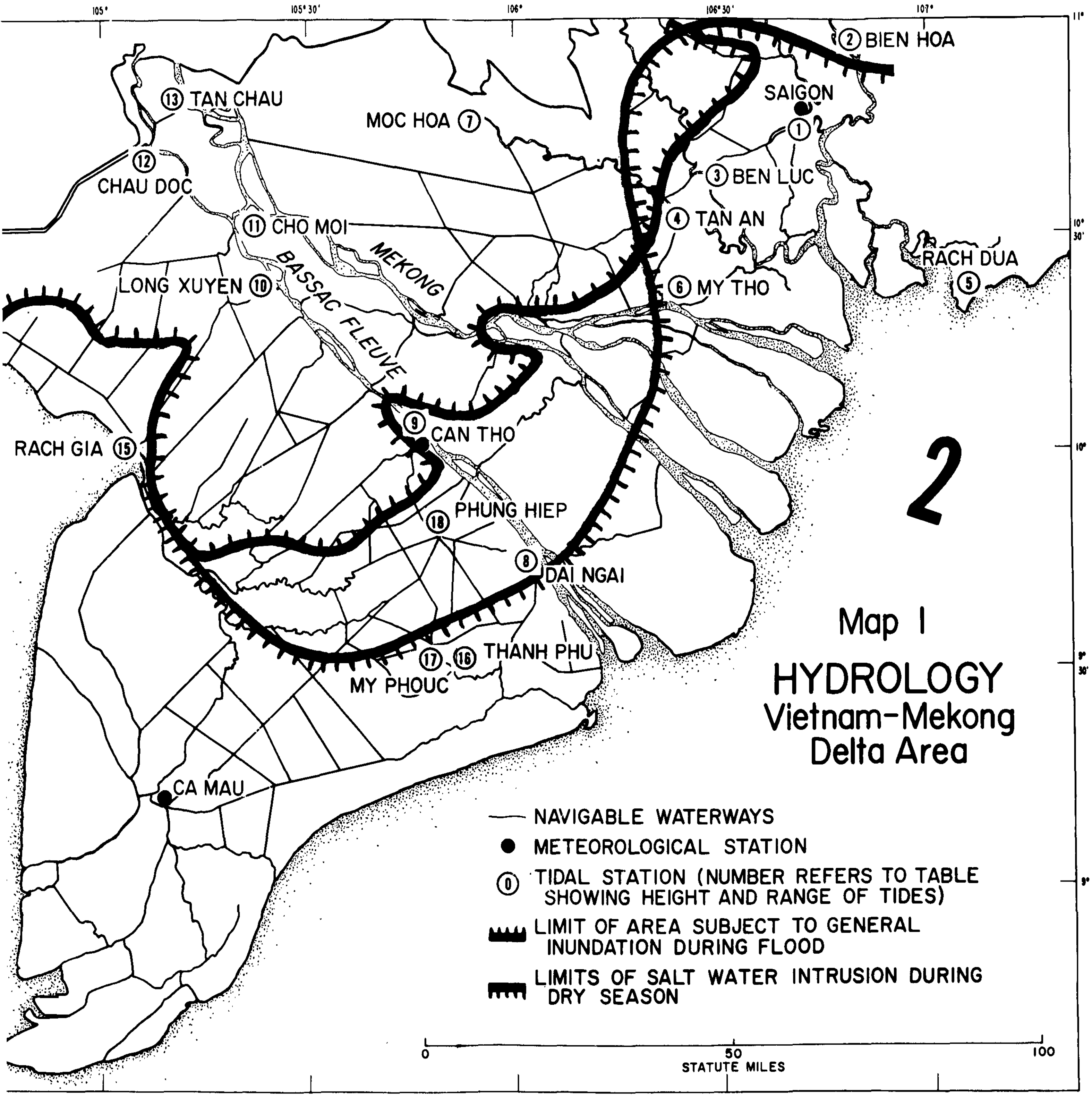
105°
105° 30'
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107°
11°
10° 30'
10°
9° 30'
9°
② BIEN HOA
SAIGON
①
⑬ TAN CHAU
MOC HOA ⑦
⑫
CHAU DOC
③ BEN LUC
④ TAN AN
⑪ CHO MOI
MEKONG
BASSAC FLEUVE
RACH DUA
⑤
LONG XUYEN ⑩
⑥ MY THO
⑨
CAN THO
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2
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⑱
⑧
DAI NGAI
Map I
HYDROLOGY
Vietnam-Mekong
Delta Area
⑰ ⑯ THANH PHU
MY PHOUC
CA MAU
NAVIGABLE WATERWAYS
METEOROLOGICAL STATION
TIDAL STATION (NUMBER REFERS TO TABLE SHOWING HEIGHT AND RANGE OF TIDES)
LIMIT OF AREA SUBJECT TO GENERAL INUNDATION DURING FLOOD
LIMITS OF SALT WATER INTRUSION DURING DRY SEASON
0
50
100
STATUTE MILES

rains generally extends from May through October throughout the Delta area, the high-water or flood season occurs in September and October. At that time the accumulated floodwaters spread over a large part of the Delta, as indicated. This flooding assumes the proportions it does because the Mekong, in addition to draining the southern part of Vietnam, drains a vast watershed that includes parts of Cambodia, Laos, Thailand, and China. The monsoon brings exceptionally heavy rainfall to the mountainous portions of these areas, thus contributing greatly to the heavy flow of the Mekong and the flooding of the Delta. In October, the rise in the level of the Mekong may be as much as 4 meters or more at the Cambodian-Vietnam border. This situation will be illustrated in chart form in the discussion of tidal influences.

Tides

There is a strong tidal influence on water levels throughout most of the Delta area. Moreover, the twice-daily tidal flows have a significant influence on bank and bottom conditions and on the velocities of currents, both in the natural tidal streams and in the multitude of man-made navigation and drainage canals in the Delta. The tides therefore have an extremely important bearing on the feasibility of navigation and on the type of craft required for effective use of much of the waterway network. Particularly during the low-water season, it is impossible to move on many of the major canals during periods of low tide other than by small, very shallow-draft craft, such as sampans.

The heights and ranges of tides at a selected number of stations are given in Table II. These data have been derived from records for the year 1963. In a few cases, records for the entire year were not available. The locations of the tidal stations are also indicated on Map 1.

The specific influence of tides on water levels inland on many of the smaller streams and the canals depends greatly on the gradient and the shape and orientation of the waterways in question, on the number of channels connecting with the sea and with the major rivers, and on the tidal stage of the major rivers. The feasibility of certain types of small craft operations on many of the waterways would depend directly on the time of day and stage of the tide. Unfortunately, reliable tidal records are available for only a few stations and, generally, only those located on the coast or on the major rivers. The planning of small craft operations, therefore, often depends heavily on first-hand knowledge of local tidal characteristics. At best, existing tide tables and records generally provide an inadequate basis for estimating the probable tidal conditions for a specified time at a particular location away from a major stream.

Table II

COMPARISON OF DAILY HEIGHTS AND RANGES OF TIDES AT SELECTED STATIONS
South Vietnam - Mekong Delta Area

Map Number[a]	Station	Tidal Range (meters) Maximum	Tidal Range (meters) Average	Tidal Range (meters) Minimum	Tidal Range (meters) Average during Flood	Height of Tide (meters) Maximum	Height of Tide (meters) Minimum
1	Saigon	3.0	2.2	1.5	2.0	1.8	-2.3
2	Bien Hoa	2.5	2.0	1.2	2.0	1.6	-1.7
3	Ben Luc	2.4	2.0	1.3	1.5	1.2	-1.8
4	Tan An	2.2	1.8	1.2	1.5	1.4	-1.5
5	Rach Dua	4.0	2.5	1.4	1.4	1.5	-3.0
6	My Tho	2.6	1.5	1.1	1.6	1.6	-1.8
7	Moc Hoa	1.3	0.8	0.0	0.2	3.2	+0.4
8	Dai Ngai	2.7	2.4	2.0	2.3	2.0	-1.9
9	Can Tho	2.5	2.0	0.8	0.8	1.9	-1.2
10	Long Xuyen	1.5	1.0	0.3	0.3	2.5	-0.9
11	Cho Moi	1.5	1.0	0.2	0.2	2.7	-0.6
12	Chau Doc	1.2	0.5	0.0	0.1	3.9	-0.5
13	Tan Chau	1.0	0.75	0.0	0.1	4.4	-0.3
14	Ha Tien	2.0	1.3	0.5	0.5	1.6	-1.0
15	Rach Gia	1.2	0.75	0.3	0.3	1.0	-0.6
16	Thanh Phu	2.2	1.8	0.9	0.9	1.2	-1.4
17	My Phouc	2.2	1.6	1.0	-	1.0	-1.6
18	Phung Hiep	2.1	1.5	0.4	0.4	1.2	-1.3

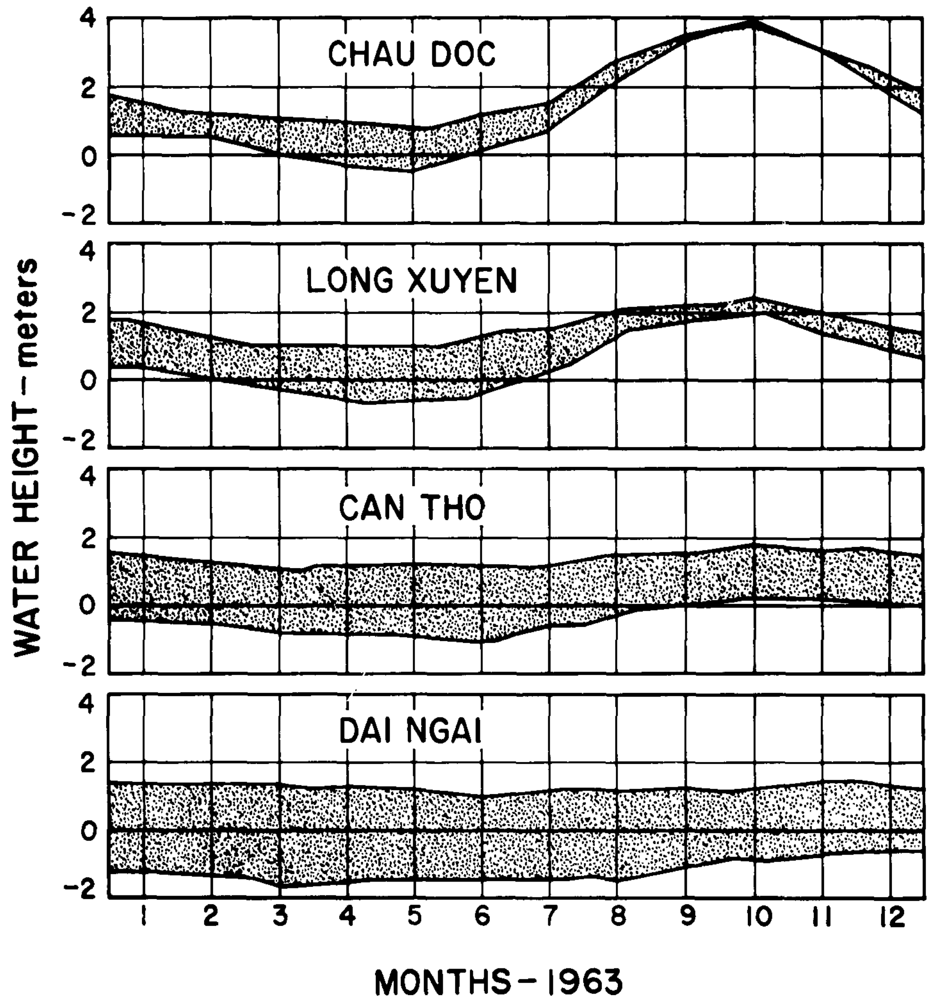
a. Number refers to location of station on map showing hydrology of Delta area.

Source: BIỀU ĐỒ MỰC NƯỚC HÀNG NĂM, Năm, 1963.

The magnitude of differences in water depth between high and low tide conditions is suggested in Table II. Daily tidal ranges vary, depending on the month and the particular location. At Saigon, for example, the daily range may be as great as 3 meters. The average is 2.2 meters. At Rach Gia on the Gulf of Siam (see Map 1), the daily tidal range is much less than at Saigon, the maximum being only 1.2 meters. In Fig. 1, the average daily tidal range is shown by months for four selected stations along the Bassac River. These curves are generalized from the record of daily extremes, but they indicate clearly the difference between the tidal range encountered in the lower Delta (at Dai Ngai) and that experienced on the upper reaches of the river near the Cambodian border (at Chau Doc). At Dai Ngai the daily range is up to 3 to 4 meters, while at Chau Doc the range is closer to 1 meter. Figure 1 also illustrates clearly the rise in water level on the Bassac toward the end of the rainy season (October) and the almost complete damping of the daily tidal range at Chau Doc during this high-water period.

As indicated, tides affect the water levels of streams, marshes, swamps, and canals over a considerable part of the Delta. During the dry season salt-water intrusion becomes a major problem in the lower Delta. The overall area subject to at least occasional salt-water intrusion is shown on Map 1. As will be noted in a later discussion, the near-coastal areas are subject to frequent, if not daily, salt-water inundation at high tide. These areas are generally mangrove swamps. As the map indicates, occasional salt-water intrusion occurs considerable distances inland from the coast, and this tidal influence extends over large expanses of fresh-water swamp, marsh, and even paddy land. In these areas, tidal conditions necessitate the erection of control devices, such as culverts with automatic flapgates, tide gates to permit navigation in larger canals, and occasional small dams across tidal sloughs, to control salt-water intrusion and protect agricultural land. Such devices naturally have a considerable bearing on the extent to which government or local defense forces in particular areas can depend on water transport for tactical or supporting operations. The limit of salt-water intrusion is of further interest with respect to surface movement in that it suggests the expanse of area over which tidal streams would be encountered--a factor of particular importance since tidal streams frequently have extremely soft mud banks that are difficult or impossible for an amphibian vehicle to traverse in exiting a waterway.

Currents in the Mekong and the Bassac are sharply affected by the seasonal changes in water level and by the tides. During the high-water season maximum velocities of 5 miles per hour are sometimes reached, as for example, at My Tho on the Mekong and at Can Tho on the Bassac. During the high-water season the major rivers flow continually downstream, but



Source: BIỂU ĐỒ MỰC NƯỚC HÀNG NĂM, Năm, 1963.

Fig. 1 AVERAGE DAILY RANGE OF TIDE AT SELECTED STATIONS ON THE BASSAC RIVER during seasonal low-water periods the flow of these rivers reverses with the tide. At My Tho, for example, the upstream flow reaches 1 mile per hour. Currents in the tributaries and canals depend on specific depths, curves, particular channel lengths, and the action of the tides through distributary waterways. Velocities of up to 5 or 6 miles per hour are not uncommon on both major rivers and on the canals.

Navigability

The waterways shown on Map 1 as comprising the waterway network in the Delta area were not differentiated as to depths or as to the allowable drafts for waterborne craft. On Map 2, the same structural network is indicated but with individual segments of the waterways differentiated as to the estimated maximum low-water safe draft. The total length represented by waterways having controlling depths that limit the allowable safe draft to specified maximums is shown in Table III, both in absolute terms (kilometers) and as a percentage of total waterway length. The cumulative percentage of total waterway length exceeding specified allowable drafts is also indicated. Canals and lesser waterways have been grouped separately from major rivers to highlight the significant differences in allowable drafts on canals and on the rivers. For example, only 42.8 percent of the canal system has an allowable draft exceeding 2 meters, whereas 82 percent of the total river length has an allowable draft of over 2 meters. Moreover, it is noted that almost 30 percent (28.8) of the canal system has an allowable draft of only 0.6 to 1.0 meters in a low-water condition.[1] As will be noted on Map 2, which distinguishes navigable waterways by allowable low-water draft, the waterways with the shallower drafts tend to be concentrated in the central portion of the Ca Mau Peninsula.

The information presented above regarding depths, or allowable drafts, on various canals and sections of waterways must be considered with a certain amount of reservation. Examination of information in the files of the Department of Navigation (Ministry of Public Works) indicates that the data reported in the National Intelligence Survey on depths of waterways

1. These percentage figures have been derived from NIS data showing the limiting draft of each segment of the waterway network. Usually, the draft is limited by water depth at a particular point in a given segment. Average depth throughout the length of a segment is meaningless. The average length of the segments for which limiting drafts were specified is about 17 kilometers (excluding major rivers).

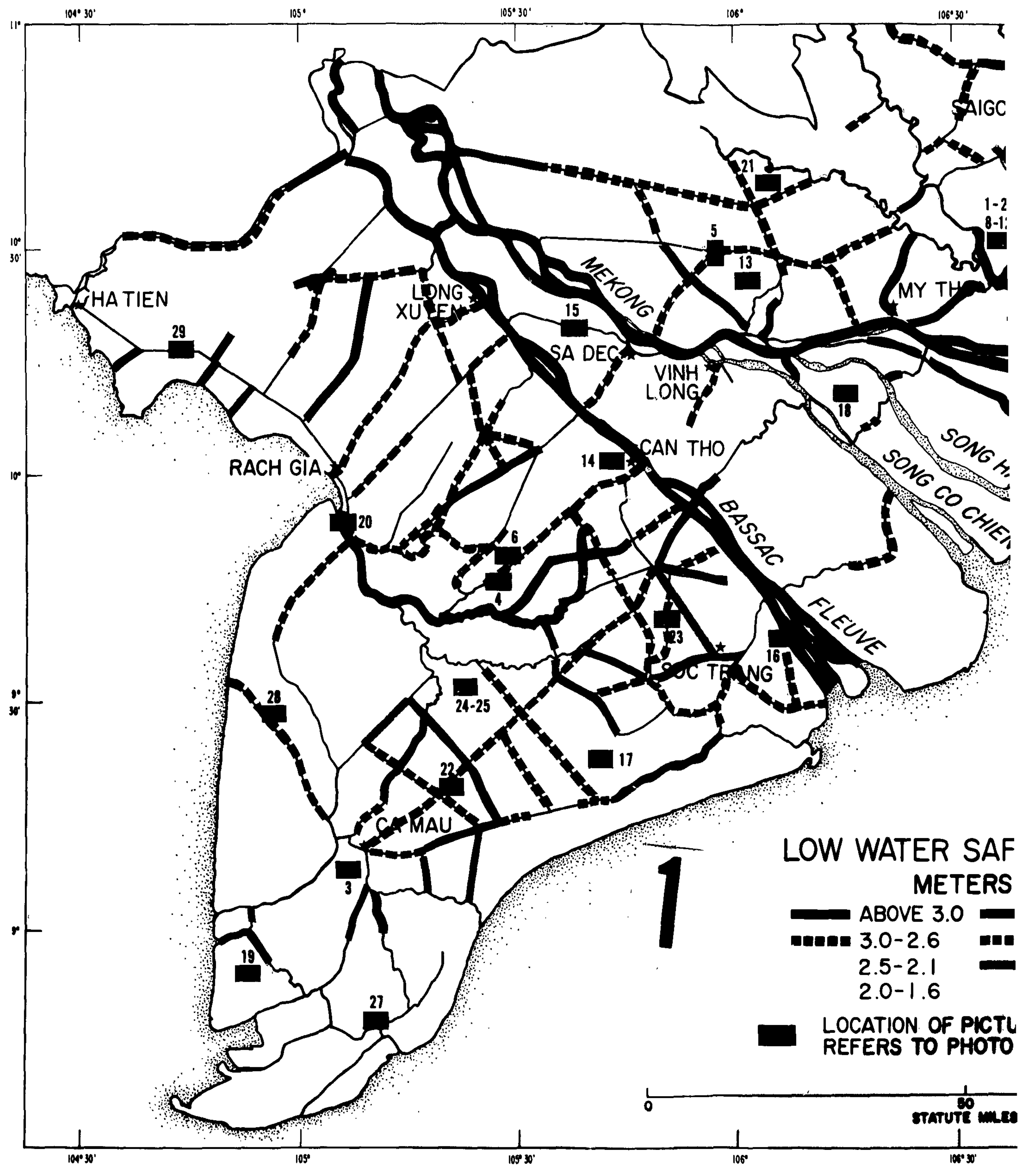
Table III

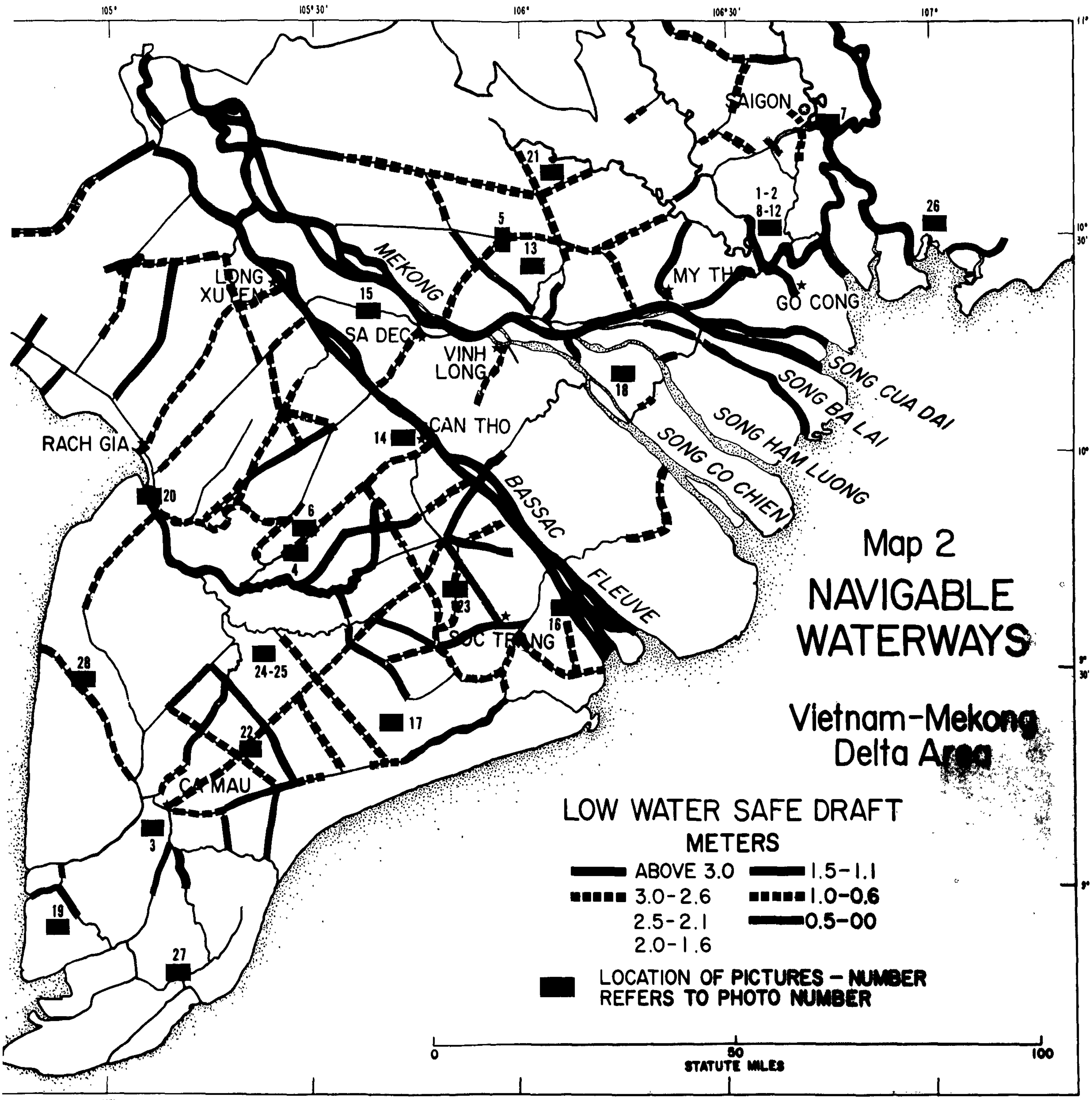
PERCENTAGE DISTRIBUTION OF TOTAL WATERWAY LENGTH CONTROLLED BY MAXIMUM ALLOWABLE SAFE DRAFTS, AS SPECIFIED
South Vietnam - Mekong Delta Area
(Low-Water Condition)

Specified Allowable Draft (meters)	Total Length[a] (kilometers)	Percentage of Total Waterway Length	Cumulative Percentage of Total Waterway Length
	Canals and Lesser Waterways		
Above 3.0	156.6	4.5	4.5
2.6 - 3.0	389.3	11.3	15.8
2.1 - 2.5	930.6	27.0	42.8
1.6 - 2.0	262.0	7.6	50.4
1.1 - 1.5	667.1	19.3	69.7
0.6 - 1.0	993.0	28.8	98.5
0.0 - 0.5	52.7	1.5	100.0
	3,451.3	100.0	
	Major Rivers		
5.1 and above	71.0	5.6	5.6
4.1 - 5.0	228.0	17.9	23.5
3.1 - 4.0	402.3	31.6	55.1
2.6 - 3.0	0	0	55.1
2.1 - 2.5	349.2	27.4	82.5
1.6 - 2.0	117.4	9.2	91.7
1.1 - 1.5	105.4	8.3	100.0
	1,273.3	100.0	

a. Total length of individual segments having a depth that limits safe draft to a maximum falling within the specified range (column 1).

Source: Derived from data in Inland Waterway Section of the NIS.


104° 30'
105°
105° 30'
106°
106° 30'
11°
10° 30'
10°
9° 30'
9°
HA TIEN
29
LONG XUYEN
15
SA DEC
VINH LONG
MEKONG
21
5
13
18
RACH GIA
20
14
CAN THO
BASSAC
FLEUVE
6
4
23
16
SOC TRANG
28
24-25
17
22
CA MAU
3
19
27
1
METERS
ABOVE 3.0
3.0-2.6
2.5-2.1
2.0-1.6
REFERS TO PHOTO
0
50
STATUTE MILES


Map 2
NAVIGABLE WATERWAYS
Vietnam-Mekong Delta Area
LOW WATER SAFE DRAFT
METERS
ABOVE 3.0
3.0-2.6
2.5-2.1
2.0-1.6
1.5-1.1
1.0-0.6
0.5-00
LOCATION OF PICTURES - NUMBER REFERS TO PHOTO NUMBER
0
50
100
STATUTE MILES
105°
105° 30'
106°
106° 30'
107°
11°
10° 30'
10°
9° 30'
9°
SAIGON
MY THO
GO CONG
LONG XUYEN
SA DEC
VINH LONG
CAN THO
RACH GIA
SOC TRANG
CA MAU
MEKONG
BASSAC
FLEUVE
SONG CUA DAI
SONG BA LAI
SONG HAM LUONG
SONG CO CHIEN
1-2
8-12
3
4
5
6
7
13
14
15
16
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18
19
20
21
22
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24-25
26
27
28

2

reflect primarily design data rather than the actual dimensions or depths of the canals at a specified time (the NIS is dated 1961). Such data do not provide valid information on depths, even assuming a continuing program of dredging. Furthermore, annual maintenance has not been carried out on all canals on a continuing basis, and for the past two years, because of the security problem, no canal dredging has been undertaken. Thus, many canals have now had no maintenance dredging for many years. Thus, silting is and will be an increasingly significant problem influencing the feasibility of achieving greater use of the waterways other than by employing craft having shallower drafts than the landing craft currently used by the RAG's.

The study team compared a number of canal profiles, showing water depths before dredging, immediately after dredging, and several years after dredging, to gain some appreciation of the characteristics of sediment deposition in the canals. For those canals that cut across the main river systems (the Bassac and the Mekong), sediment deposition occurs mainly toward the middle of the length of the canal. This is caused by tidal inflow from both ends, moving sediments toward the middle. Ebb tides do not remove the sediments in the center portion but do tend to keep the ends of a canal free of deposition. The amount of sediment deposited varies from one canal to another, but in many instances the deposit will reach low-water level in a period of perhaps 10 years. Some of the profiles showed accumulations of 0.5 meter in one year--not throughout the canal but in critical spots.

The extent of sedimentation and the time it takes for navigation to be affected by such deposits vary from canal to canal and from one part of the country to another. At the present time there are numerous segments of major canals that cannot be navigated under low-water conditions by the larger canal boats and by the landing craft used by the Vietnamese Navy. In these instances, circuitous routing is necessary or, if impossible, a delay is encountered in waiting for high water. In certain types of military movements, such delays are unacceptable.

The waterway network delineated on Map 2 is that generally represented as the navigable waterway system. The total length of this system, excluding the larger rivers (the Bassac and the Mekong and their several major channels; the Vaico Occidental and Oriental; the Soirap and the Saigon; and the Dong Nai), is about 3,450 kilometers (as indicated in Table III). Inclusion of the major rivers adds another 1,270 kilometers to the total length of the navigable waterway system.[1] It is important to note, however, that the Delta is literally crisscrossed with lesser streams and canals, including irrigation and drainage ditches, and these are not included in the system portrayed on the map.

These lesser waterways offer some potential for military transportation employing small craft or sampans of very shallow draft. Sampans are important means of local movement for the civilian populace, and they are clearly of importance to the V.C. The Communists make extensive use of both powered and unpowered sampans. Moreover, as noted earlier, the occurrence of small waterways has a significant influence on the problem of off-road movement.

An appreciation of the overall density of waterways in the Delta area can be gained by comparing the average spacing between major streams and canals with the average spacing between all waterways, including minor canals and ditches (not shown on Maps 1 and 2). Moreover, significant differences in relative densities of waterways are found in different parts of the Delta and in different environmental situations. For example, in a detailed sampling and analysis of conditions in paddy land northeast of the Bassac, it was found that major waterways occur with an average spacing of about 4.3 kilometers,[2] as shown in Table IV. When all waterways are taken into account, including minor canals and irrigation ditches, the average spacing drops to less than 1 kilometer, as indicated. In a detailed sampling of paddy area southwest of the Bassac, the average spacing between major waterways was found to be a little over 8 kilometers, but the spacing drops to only 6/10 of a kilometer when all waterways are considered. The marsh area of the Plain of Reeds has a relatively sparse network of major waterways, but there is a much greater density of small waterways. It is thus seen that the landscape is much more densely cut by waterways than is suggested by maps that show only the navigable waterway system.

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1. The system of navigable waterways represented on the map is that described in the Inland Waterway Section of the NIS. The NIS information appears to be in essential agreement with detailed information on the structure of the waterway system obtained from the Ministry of Public Works (Departments of Navigation and Inland Navigation Service) in Saigon.
2. Spacing was determined by analyzing photo and map coverage of 5-minute quadrangles and establishing the number of water crossings encountered on the diagonals connecting the corners of the quadrangles. The average number of crossings per diagonal was the characteristic used in summarizing conditions in the sample areas, or quadrangles.

Table IV

DENSITY OF WATERWAYS
South Vietnam - Mekong Delta Area

Type of Surface Conditions	Average Spacing between Waterways (kilometers) Major Waterways Only[a]	All Waterways[b]
Paddy (northeast of Bassac)	4.34	0.95
Paddy (southwest of Bassac)	8.28	0.62
Marsh (Plain of Reeds)	17.80	0.97

a. Streams and canals 18 meters or wider.
b. Including lesser streams and canals and irrigation ditches.

Source: Stanford Research Institute on the basis of 1:50,000 topographic mapping and 1:40,000 aerial photography. See text for methodology.

On the map of navigable waterways (Map 2), the locations of a number of photographs are indicated. The photographs, included as Appendix A to this report, serve to illustrate various conditions of the environment, including certain characteristics of the waterways as well as surface conditions. A number of the photographs show a portion of the navigable waterway system (indicated on Map 2) and minor canals and drainage ditches. Particular examples are Photographs 5, 7, 8, 13, 15, and 18. In some of these photographs, sampan traffic is visible (for example, Photo 18).

In an examination of the characteristics of the waterways as they bear on the potential for greater use of this network for military purposes and on the types of craft that might thus be employed, it is essential to consider the occurrence of certain types of restrictions or obstacles other than waterway depths. Even where allowable drafts are adequate for larger craft, navigation is sometimes impossible because of heavy, floating vegetation or other obstacles in the waterways. In Photo 6A, for example, a large canal is seen to be almost completely clogged by heavy vegetation; small sampans can and do make their way through narrow channels in such vegetation, but it would be difficult or impossible for larger craft to move through these channels. Such vegetation is not found in all canals by any means, but its presence is sufficiently widespread to be a matter of concern in considering the possibility of placing more dependence on waterborne transportation. A close-up view of the type of vegetation encountered in the waterways is shown in Photo 6B. Isolated clumps of such vegetation can generally be pushed aside, but their presence necessitates slow going, and there is considerable difficulty with fouling of propellers. Vegetation would generally appear to be a greater problem in the minor canals than in the larger canals of the navigable waterway system. Photographs 15, 19, and 23 illustrate the clogging effect of vegetation in minor waterways.

In many parts of the Delta, the waterways are not infrequently blocked by man-made barriers of one sort or another. The Viet Cong often construct barriers that preclude movement by the larger canal craft but permit passage by sampans. The occurrence of barriers in the larger navigable canals of the Delta is illustrated in Photographs 5A and 5B. Such barriers may be simple earthen dams. Others are built by driving trees into the canal bottom and filling in the area with shrubs or other materials, thus making removal more difficult. Various means of removal can and have been employed; however, removal takes time. Furthermore, removal may be extremely hazardous, both because explosives are sometimes planted in the barrier and because the danger of ambush may be intensified while the barrier is being removed.[1]

In some waterways, particularly the smaller channels, fish traps also pose a considerable obstacle to waterborne movement. Channels normally are not totally blocked, but in conditions of poor visibility or with high-speed craft the fish traps could pose a hazard or limitation to movement. Close study of Photo 17 reveals a large number of V-shaped fish traps extending almost the entire width of a relatively small stream (not part of the navigable waterway system). In Photo 27 a number of fish traps can be seen extending considerable distances into a major waterway. While not obstructing movement, such traps would have to be avoided. This situation could cause something of a problem if night operations or high-speed movements were attempted.

The potential danger of ambush along the waterways is, to a considerable extent, a function of the nature of the bank cover. As noted, the banks of the waterways are covered by dense foliage or lined by trees and houses. This typical condition may be seen in many of the photographs in the appendix. Throughout most of the Delta area, lines of settlement are characteristically found along both canals and natural streams.

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1. A very useful analysis of possible means of handling barriers in the waterways has been completed by Research Analysis Corporation. (James W. Johnson, "River and Canal Ambush Problems, Republic of Vietnam, 1962 (U)," Research Analysis Corporation, Staff Paper RAC-SP-4(SEA) Draft, March 1963, SECRET.)

Overall, with respect to the characteristics of the waterways and the potential feasibility of placing large-scale dependence on water craft for tactical movements, it must be observed that there would be a number of severe problems to be overcome. First, a substantial part of the waterway system is characterized by very shallow depths, particularly at the season of low water and at low tide. Second, there are numerous obstacles in the waterways, including floating vegetation, V.C. barriers, and fish traps, and these obstacles can and do severely restrict the flexibility of waterborne movement off the major rivers. Third, there is the ever-present danger of ambush because of the dense vegetation and pattern of development that characterize the banks of much of the waterway system. Waterborne military movement, like military traffic on the roads, is easily and frequently ambushed. Moreover, in certain cases the waterways, like the roads, are simply blocked and made unusable. Thus, the potential for improved mobility in the Delta area may be quite dependent on the possibilities for achieving improved off-road mobility. Surface conditions contributing to the problem of off-road movement are therefore considered next.

Surface Conditions

Improving capabilities for off-road and off-canal movement may be a major prerequisite to a general improvement in mobility in the Delta area. Both waterborne and road-bound movements are highly channelized. As a result, freedom of movement is readily restricted, and many areas are normally quite inaccessible by surface means of transport. Also, roads and waterways offer many opportunities for ambush, and movements along these arteries are frequently ambushed by the Viet Cong. A greater availability of off-road vehicles could make possible increased freedom of movement with less likelihood of ambush. However, the realization of such improvements would probably depend not only on the availability of vehicles capable of off-road operation but also on the establishment and maintenance of a high level of training and discipline of both vehicle operators and tactical user units to ensure that such movements are actually made off-road. There have been numerous instances in the Delta where armored personnel carriers (M-113's) have been ambushed in road movements that technically could have been made off-road. Admittedly, off-road movement is often somewhat slower than road travel and is frequently destructive of crops.

Despite these considerations, there appear to be situations in which improved or greater capabilities for off-road movement could provide the basis for more effective military operations. The physical feasibility of achieving greater capabilities for off-road movement depends on the particular characteristics of the surface over which the vehicles must operate and on the performance characteristics of the off-road vehicles or other platforms that are considered for potential use. In the remaining portion of this section, information is developed on the nature of the surface conditions that influence the feasibility of off-road vehicle operation or performance in different parts of the Delta.

Critical Factors Affecting Off-Road Mobility

Virtually the entire study area is a low, nearly level plain subject to extensive and prolonged inundation. Only in the westernmost portion of the Delta are there any terrain features rising above the plain. In the Rach Gia - Ha Tien - Chau Doc triangle (see Map 1) are a few isolated hills, the highest of which rises to a little over 700 meters. Therefore, rugged terrain and high relief, as such, are not factors influencing the potential for off-road movement or improved mobility in the Delta area. Rather, the major factors influencing the feasibility of off-road movement by surface vehicles of one type or another are (1) soil trafficability, (2) microrelief, and (3) vegetation cover.

Soil Trafficability. The trafficability of ground surfaces depends fundamentally on the moisture content of the soil, or the state of the ground. During the extended wet season, soil conditions everywhere in the Delta are extremely adverse for off-road vehicular movement. During the dry season, the ground surface generally becomes hard and will readily support heavy vehicles. However, even during the dry season, the ground remains wet over large areas because of poor drainage, and conditions of trafficability are highly unfavorable. Moreover, during the dry season the edges of rivers and streams and of some of the canals remain wet, thus frequently making it difficult or impossible for vehicles to cross or exit waterways.

Certain off-road vehicle designs are found to be reasonably well suited to the adverse trafficability conditions of the Delta and are therefore generally mobile even in the wet season. The M-113, for example, is able to operate well in flooded paddy land in much of the Delta area. In the lower Ca Mau area, however, it is found that the M-113 is often unable to move across flooded paddy, especially toward the end of the wet season when the soil has been flooded for a long period. After prolonged flooding, the acid alluvial soils and the highly acid muck and peaty soils of the lower Ca Mau area become too weak to support tracked vehicles as heavy as the M-113. Reports from the field indicate that the mud that develops in the paddy land in this area after prolonged inundation seems bottomless, and that the M-113 generally bogs down under these conditions and becomes immobilized. In much of the Delta north and east of the Bassac, however, soil conditions are somewhat different. The soils in that part of the Delta are generally characterized as more recent, undifferentiated alluvial soils. Even when wet, they appear to maintain a reasonably firm base a few inches below the paddy mud, thus affording significantly better conditions of trafficability.

The major point to be stressed, however, in describing soil conditions in the Delta is that soil trafficability is everywhere difficult. Consequently, any vehicle being considered for employment in the Delta should have the best possible performance over very weak soils.

Microrelief. A second major group of factors influencing off-road movement comprises features of microrelief, or surface geometry. Even if vehicles are capable of operating over very weak soils, they may be immobilized by the various types of obstacles, such as stream and canal banks, paddy dikes, raised roadbeds, and narrow ditches, that must be surmounted or crossed in off-road operations in the Delta area. Frequently, however, it is not simply the height or the slope of such an obstacle as a canal bank or a major paddy dike that immobilizes a vehicle. Rather, it is the resistance of the obstacle, coupled with soft soil conditions and inadequate traction. With firmer soils and better traction, such an obstacle could be crossed. Canal and stream banks generally present the most difficult obstacles because they often are composed of deep, soft tidal mud having very poor bearing capacity for vehicles as heavy as an M-113 and affording very poor tractionability.

An appreciation of the conditions of stream and canal banks and the nature of the obstacle they present can best be gained by examining a few photographs of representative situations in the Delta area. The banks of tidal streams often slope very gently but are constituted of extremely soft tidal mud. Such a stream bank is shown in Photo 1 (in the appendix). A vehicle as heavy as an M-113 simply cannot cross a bank such as this without external engineering-type assistance. The problem is not the steep or high bank per se but the soft mud that will not support the vehicle or afford proper traction. Under high-water conditions on tidal streams, banks such as that shown in Photo 1 would not be evident, but they are there and the problem of weak soils would remain to be encountered much as under low-water conditions. Photo 2 is a close-up portrayal of the soft mud along a tidal stream.

Many of the canals have steep banks above the general water level, as in Photos 3 and 4. Below the water level there will often be more gently sloping banks with soft mud. Both of these photos show canals with a small tidal influence, and at low tide the soft mud banks are only partially exposed. Again, the soft mud creates major problems for vehicles attempting to gain traction. A severe lack of traction also occurs in those cases where there is a deep channel and the amphibian is floating as it approaches the bank. Thus, both a deep, steep bank below the waterline and a gentle bank (normally with mud too soft to support the weight of a vehicle) present problems that are quite difficult to overcome. A steep bank above the waterline can often be surmounted if good traction is available. If too high to be readily surmounted, it can be shoveled down. In short, for a vehicle with a relatively good capability for crossing or exiting streams to be employed with any degree of success off-road, it must also have design features that will provide good flotation and traction on very soft muds and a chassis configuration that will permit it to approach and obtain traction on steep banks.

Vegetation Cover. The third major factor influencing the feasibility of off-road movement is the type of vegetation cover. Within the Delta, essentially three major types of situations are encountered with respect to vegetation and the attendant problems of surface movement. These types of situations, as classified by the predominant type of vegetation and surface conditions, are paddy land, marshland, and forest or swamp forest. There is substantial variation in surface conditions from one classification to another and, to a lesser extent, within each of these general classifications.

To determine the prevalence and distribution of the various conditions that might be encountered in the Delta area, a 5-minute grid system was superimposed over the entire area of interest. Each quadrangle thus formed was classified as a unit with respect to predominant vegetation and surface conditions. The predominant vegetation in each quadrangle (which measures roughly 5 x 5 nautical miles) was determined through detailed analysis of the 1:50,000 topographic map coverage and the aerial photography. A photo mosaic covering the entire Delta area at a scale of 1:40,000 was constructed, and detailed photo mosaics at a scale of 1:8,000 or 1:10,000 were developed for a number of different sample areas within the Delta. Interpretation of the mapping and the photo coverage was greatly facilitated by low-level observation flights and on-the-ground observations undertaken in a number of widely separated parts of the Delta during the field trip.

The relative occurrence and distribution of paddy, marsh, and forest throughout the Delta area are indicated in Table V. Most of the Delta may be classified as paddy land or predominantly paddy land. For example, 64 percent of the 5-minute quadrangles are classified as paddy or as predominantly paddy plus various types of forest or marsh. However, paddy

Table V

CLASSIFICATION OF PREVAILING SURFACE CONDITIONS
South Vietnam - Mekong Delta Area

Classification Grouping	Number of 5-Minute Quadrangles			Percentage Distribution by Classification Grouping		
Rice Paddy			362			64.3%
Rice paddy		130			23.1%	
Predominantly paddy + forest		126			22.4	
Predominantly paddy + mangrove	36			6.4%		
Predominantly paddy + swamp forest	8			1.4		
Predominantly paddy + plantation or tree lines	65			11.6		
Predominantly paddy + brushwood	17			3.0		
Predominantly paddy + marsh		106			18.8	
Marsh			68			12.1%
Marsh		19			3.4	
Predominantly marsh + paddy		49			8.7	
Forest and Swamp Forest			133			23.6%
Forest and swamp forest		67			11.9	
Mangrove	46			8.1		
Swamp forest	4			0.7		
Predominantly swamp forest + mangrove	1			0.2		
Brushwood	15			2.7		
Dense forest	1			0.2		
Predominantly forest + paddy		66			11.7	
Predominantly mangrove + paddy	25			4.4		
Predominantly swamp forest + paddy	15			2.7		
Predominantly brushwood + paddy	19			3.4		
Predominantly dense forest + paddy	3			0.5		
Predominantly plantation + paddy	4			0.7		

a. Each 5-minute quadrangle has been classified as a unit area on the basis of Army Map Service 1:50,000 topographic mapping and the 1:40,000 photo mosaic constructed by the Institute study team.

Source: Stanford Research Institute.

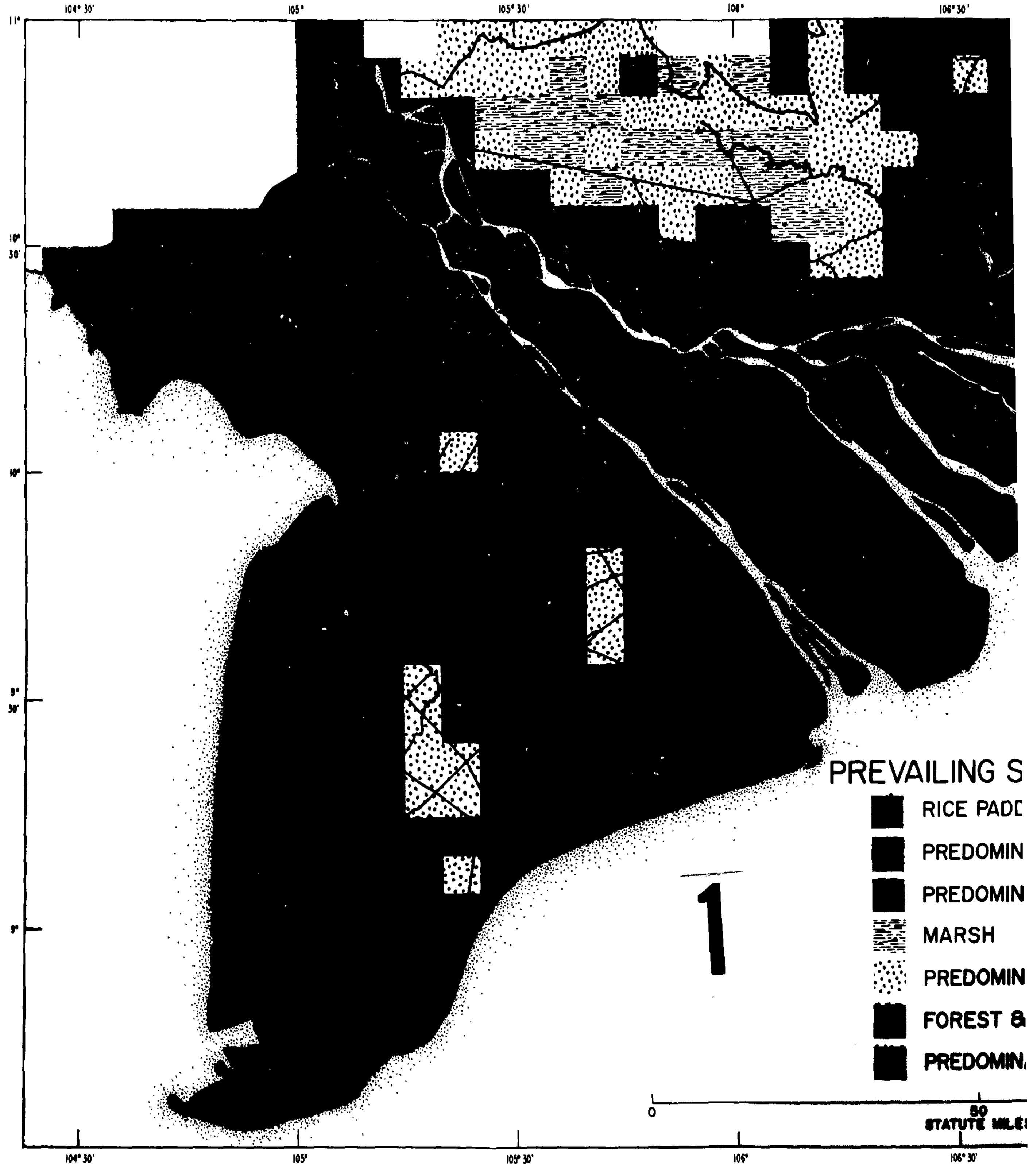
is the dominant feature of 64 percent of the area. For the remainder of the Delta, 12 percent of the land area is classified as marsh or as predominantly marsh with paddy land, while 24 percent is indicated to be forest and swamp forest or predominantly forest plus paddy. Within the rice or paddy area is found considerable plantation land, as in the area between the lower parts of the Mekong and Bassac rivers.

The geographic distribution of paddy, marsh, and forest land is shown on Map 3. In the vast area characterized as predominantly paddy land (shown in blue on the map), it will be noticed that there is a considerable occurrence of trees and marsh (symbolically represented). In the paddy area northeast of the Bassac, there tends to be a heavy tree development along the waterways. Much of the area classified basically as rice actually is a combination of rice and marshland, particularly in the transition areas between the paddy (indicated in blue) and the marsh (indicated in yellow). Several kinds of forest and swamp forest are found in the Delta, although not differentiated on the map. Specific conditions in each of the major classifications will be considered briefly in the following paragraphs.

Characterization of Prevailing Conditions

Paddy Land. Rice cultivation predominates over a great part of the Delta, as the information in Table V and on Map 3 indicates. It is found, however, that there are significant differences in the general characteristics of rice cultivation and of paddy land in various parts of the Delta. There are three specific types of rice cultivation in the area. In the most common situation, the rice is seeded in June or July, transplanted in August or September, and harvested in December or January. This is the usual pattern in areas away from the major rivers and from recurring heavy inundation. In areas close to the rivers (near Vinh Long, Sa Dec, and Can Tho), rice fields generally undergo two transplantings. Floods up to a foot and a half spread freely over these fields, and the two transplantings are necessary to develop tall, strong plants capable of withstanding the ebb and flow of the water. In certain areas subject to very heavy inundation (as for example farther upstream along the Bassac), where normal lowland paddy culture cannot be carried on because of the deep floodwaters, a floating rice (with stems up to 12 feet long) is grown.

Most of the rice culture in the Ca Mau Peninsula depends on rainfall rather than river floodwaters for crop production. Generally in the Ca Mau area there are relatively large, open expanses of rice unbroken by plantation or other crops, except near the Bassac and in the very southernmost portion of the peninsula (see Photographs 14, 16, 17, and 19). Individual rice fields are relatively large and field dikes are very low (similar to the low dikes shown in Photo 9). Many of these plantings are on recently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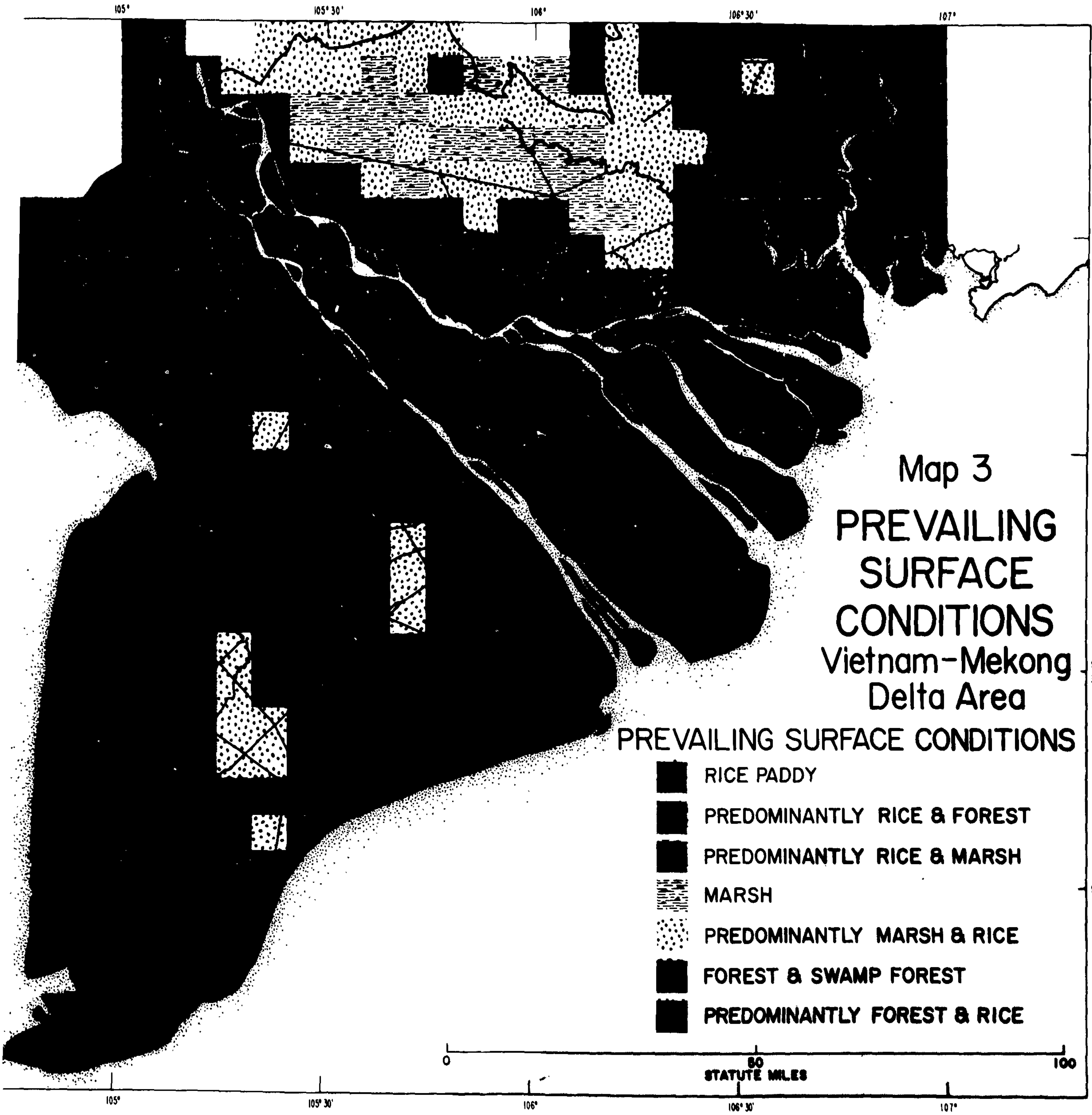

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reclaimed lands. Near the Bassac, however, fields are small and irregular and are surrounded by trees, plantations, and gardens (see Photo 14). Since large natural streams do not generally prevail in the Ca Mau Peninsula area, most of the large waterways are dredged canals running in a NW-SW direction. A few large cross-canals intersect these main canals. While some tree lines are found along both the major and minor canals, many canals are without tree lines, indicating that these canals have been recently constructed (see Photo 22). There are many small streams and canals and, as indicated, these waterways present severe problems for off-road movement. The small streams and canals afford navigation by sampan only, having widths of about 2-5 meters and maximum depths of 1-2 meters. Most of the roads and villages are located on the levees paralleling the canals and larger streams. A few tide gates are found on canals near Soc Trang. As noted earlier, the Viet Cong have constructed earth-fill dams or barriers across canals in various parts of the Ca Mau Peninsula, thus restricting and channelizing movements by craft other than sampans.

The paddy land north and east of the Bassac tends to be older and more densely settled than that southwest of the Bassac. Photos 7 and 8, for example, show an irregular pattern of very small fields, with tiny clusters of houses and trees and many small streams. The major obstacle to off-road movement in these areas would be the stream crossings. Densely developed, extended tree lines are rather infrequently found in the particular areas represented by the photographs, although they are common elsewhere in the northern Delta area. Field dikes generally are low, as shown in Photo 9; however, occasional larger dikes are encountered, as indicated in Photos 10 and 11. The low dikes, which are perhaps a foot above the surface of the water in the paddy, are readily crossed by the M-113. However, they might well cause problems for a vehicle such as the Airboat. The larger dikes, used occasionally to surround a number of individual paddies, may be 4 feet or more in height. Normally, these too can be crossed by the M-113, but frequently they are paralleled by deep, narrow ditches. These ditches would be definite obstacles to the Airboat, might well cause problems for a Marsh Screw, and would limit the movement of a GEM unless its operating height were sufficient to allow clearance over the obstacle.[1]

In much of the paddy land, the dense development of settlements and trees along the waterways presents a particularly difficult problem for off-road movement. Often, vehicular movement through the tree line would be difficult or impossible except at selected spots, and, as has been

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1. The characteristics of these vehicles are considered in a later section.

mentioned, such tree lines present good opportunities for ambush. Stream or canal crossings, generally difficult because of bank conditions, are not infrequently hampered further by the concentrations of trees and settlements. The difficulties of moving across paddy crisscrossed by tidal streams are suggested in Photo 12. Photos 13 and 15 show typical settlement patterns along the waterways. Photos 18 and 19 show mixed paddy and tree plantation. The density of the plantation would generally prevent vehicular movement. Particularly difficult conditions are presented by plantations such as the sugar cane area represented in Photo 20. In these areas and in garden plots around towns, good drainage for the crops is established by forming raised beds separated by narrow ditches, which are sometimes a meter or more in depth. Such adverse conditions for surface movement occur frequently in the paddy land but normally do not cover extensive areas.

In general, the paddy land is a good bit more favorable for vehicular movement off-road than is the marsh and forest area, as will be seen. Nevertheless, good mobility depends critically on being able to operate over soft soils and being able to cross the numerous small streams and canals. Although water crossing might be avoided in certain instances, depending on the military situation and detailed knowledge of local topography, such crossings would nevertheless be required frequently, even in limited-scope off-road movements.

It may be of some importance to note that the photography (both 1:40,000 and 1:10,000 scales) reveals a great deal of particular information on surface conditions that is not evident in the topographic mapping, even though the mapping is of very high quality. Specifically, the information the photography provides on the location of minor streams and ditches and on tree lines could be quite useful. It seems evident, therefore, that certain planning and perhaps operational advantages could be derived if high-quality, large-scale photo mosaics were made available to supplement topographic mapping, especially in critical areas. A photo mosaic that supplemented map coverage for a specific local area could be highly useful in planning vehicle operations off-road and in selecting routes to minimize water crossings and avoid likely ambush sites.

The need for improved terrain and hydrographic intelligence for effective employment of the M-113's was cited as follows in an ARPA memorandum:

> Proper terrain intelligence prior to operations is essential. Operational maps of 1/100,000 scale show the presence of most canals and streams, but do not present such vital operational factors as: actual width, depth, bank and bottom conditions, current flow, tidal state and range, and seasonal fluctuations.

Larger scale maps, such as the 1/50,000 or even the 1/25,000 series, as well as issue photomaps, present the terrain in somewhat greater detail but still lack these essential factors. Various types of vegetation are also potential barriers to cross-country movement, but these are not shown in sufficient detail to interpret this fact.[1]

Marsh. In the Delta are several extensive marsh areas, the largest of which is the Plain of Reeds. As can be seen on Map 3, this poorly drained area (actually, it is a slight depression) extends eastward from the general area of Saigon to the Mekong. On the Ca Mau Peninsula are additional marsh areas. The extent of these areas is somewhat greater than is suggested by the color coding used for marsh area on the map because much of this area is in fact mixed marsh and paddy.

In the marsh areas, soil conditions are generally even less satisfactory for vehicular movement than in the paddy areas. As expected, the marsh areas are inundated for more extended periods, and soils remain wet during much of the dry season. The marsh vegetation is dominated by sharp-bladed grasses and reeds ranging from 3 to 7 feet high. During the wet season (May through October), the appearance of the marsh is generally green. During the dry season, the vegetation dries (even though soils tend to remain wet) and appears brown or yellow. Particularly in the Plain of Reeds, scattered trees and even clumps of trees are found. Narrow strips of land along drainage canals or streams are often occupied by agricultural developments and small settlements.

Movement on foot through these marsh areas is difficult but not impossible, except during high-water season when large areas may be under a meter or two of water. For vehicular movements during these high-water periods, reliance would need to be placed essentially on the swimming or amphibious capabilities of the vehicles.[2] In the drier periods, the major obstacle to

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1. ARPA R&D Field Unit, Saigon, "Second Interim Evaluation of M-113 Armored Personnel Carrier," 29 August 1962, p. 2, KIN CONFIDENTIAL.
2. Ground vehicles considered for off-road use in the Delta area should have a swimming capability, since many streams or waterways could not be crossed by fording.

expeditious movement by off-road vehicles such as the M-113 would be the canals and streams, most of which are narrow but relatively quite deep and steep-sided. Photo 21 is a vertical view of a portion of the Plain of Reeds. Small canals and natural streams can be seen, and some brush and tree cover is evident. Also, a minor amount of agricultural development is to be noted.

Photos 22 and 23 show mixed paddy and marsh in the Ca Mau Peninsula. Again, the many small waterways are a dominant feature affecting the feasibility of off-road movement. In these pictures it is noted that reclamation is taking place and that channels are being or have recently been cut into the marsh for purposes of drainage. Photos 24 and 25, close-up views of marsh in the central Ca Mau area, illustrate clearly the nature of such topography. It is to be noted that the marshlands are not completely uninhabited. The local populace is dependent on use of the network of lesser canals and streams for transport by sampan.

Forest and Swamp Forest. In showing the distribution of paddy, marsh, and forest lands in the Delta area, Map 3 indicates clearly that forests tend to prevail along the coasts rather than inland. Several kinds of forest are found, although these are not differentiated on the map. All of the forest may be likened to swamp forest--if not premanently flooded, it is flooded periodically by tidal inundation or by waters collected during the wet season of the year.

All the forested area along the south and east portions of the Delta is mangrove. Mangrove occupies tidal lands but sometimes extends considerable distances inland, as on the southern tip of the Ca Mau Peninsula. The mangrove, forming a dense evergreen swamp in some areas, is a strip only a few yards wide along the coast at some points while at others it is a broad zone extending several miles inland. Nearest the coast the mangrove tends to be quite low, sometimes not exceeding 6 feet in height. Somewhat inland it may be 10-20 feet high, and even further inland, 50-60 feet high. Characteristically, the mangrove trees have aerial roots, which grow out in all directions from the trunk. During high tide the roots are covered by salt water. Adjacent to the sea, where the ground is covered by salt water at each high tide, undergrowth is absent and the swamp forest has a more open appearance. Further inland, where tidal inundation is less frequent (but necessary for true mangrove conditions), much low growth occurs, such as ferns (see Photos 26 and 27).

Mangroves may grow from below the level of the lowest tides to above the level of the highest tides and along estuaries penetrating far inland (see Photo 16). However, the use of the term "mangrove" can be confusing. It is used in referring both to an ecological group of species inhabiting tidal land and to the plant communities composed of these species.[1] Inland of the true mangrove areas is sometimes found what is called semi-mangrove. Semi-mangrove is characterized by extensive areas of nipa palm. As indicated, mangrove swamps are characterized by zonation of the dominant species, generally parallel with the shoreline. At the inland margin is a transition to fresh-water swamp forest of nontidal vegetation. The nipa palm often lines the banks of streams inland from the mangrove where the water is nearly fresh. The palms have short branches bearing clusters of leaves which grow 20 feet high from a large stem at or near the surface of the ground (see Photo 12). In solid stands, the nipa form a dense, almost impenetrable mass of vegetation.

Inland from the west coast of the Delta area (along the Gulf of Siam) is an extensive area of fresh-water swamp forest. In this flooded forest is found the cajuput, a thinly branched, sparsely leaved evergreen tree up to 60 feet in height. These trees are found in almost pure stands, growing perhaps 8-12 feet apart and forming a continuous, fairly dense canopy. The forest floor is generally covered by low overgrowth. This swamp forest is flooded for extended periods of time by brackish water[2] and only very rarely, at exceptionally high tides, by saline water. Photo 28 is a large-scale vertical view showing the general appearance of such forest. In this particular photo a minor navigable canal is seen, with many drainage ditches and small natural streams extending into the forest. Some habitation is noted along the canal. Movement is impossible in this type of situation except by sampan or small boat. This forest is an area of deep muck and peat soils. Areas that have been cleared are not highly productive in agricultural use.

Large areas of low trees and brushy swamp forest prevail in the northwest in the Rach Gia - Ha Tien area. Very little of this land is cultivated. These areas are therefore largely wastelands covered by reeds, tall grass, and brush. Small villages have been established near the periphery of the brushwood areas, especially on narrow strips of land along canals and streams. Most of the soils are heavy clay or silty clay and are capable

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1. See P.W. Richards, The Tropical Rain Forest, Cambridge, p. 299, 1957.
2. Brackish water is defined as that having a low degree of salinity, usually 400 to 3,000 parts per million total dissolved solids.

of supporting loads when dry, but these soils become very plastic when saturated. Drainage is slow due to some very minor undulation of terrain and the absence of a network of well-defined waterways.

It has been seen that the forest and swamp forest areas are generally characterized by dense vegetation and flooding that preclude overland movement either by vehicle or on foot. While these forested areas are not densely settled, capability to move into and within these areas maybe important, particularly because they are known to serve as V.C. base areas. Water movement would appear to be the primary means of transport. In the mangrove areas, larger boats, such as present landing craft, afford considerable access via the larger tidal streams. Elsewhere and on the myriad of smaller streams meandering through the mangrove, much smaller craft, such as sampans, are better suited.

IV POTENTIAL REQUIREMENTS FOR IMPROVED MOBILITY

In the foregoing section consideration has been given to the nature of environmental conditions in the Delta area. In this section attention is directed to the various types of military operations being conducted in, or proposed for, the Delta area, and potential requirements for improvements in mobility are identified. Any such requirements need to be specified in terms of particular types of missions or military functions.

In this assessment of possible requirements for improvements in mobility, the potential capabilities and roles of the helicopter must be considered. Conceptually, the helicopter offers a high degree of mobility, considering the extent to which surface conditions in the Delta area limit other means of movement. There are a great many helicopters presently in use in Vietnam; characteristically, helicopters afford great flexibility of employment, and they are thus found in many different types of uses in the Delta area.

The scope of this study does not include evaluation of helicopter operations per se, but it is essential to keep in mind certain characteristics of helicopter employment. It is possible that improved mobility could be achieved in certain types of operations if more helicopters were available or if the pattern of deployment and of operational procedures were further developed. However, possibilities such as these are not the subject of the research; rather, the objective here is to identify potential requirements or significant opportunities for improvements in mobility by surface means (or, generally, by means other than greater employment of the helicopter). In the discussions that follow, therefore, consideration is given primarily to potential requirements for improvements in mobility in the Delta area that could not readily or practically be achieved through employment of helicopters. Essential factors to bear in mind in this regard are the relatively high speed potentials of the helicopter, which would probably not be advantageously utilized in meeting requirements for movements over very short distances; the established pattern of basing helicopters at a few locations rather than at many dispersed points--and thus the question as to their availability to meet locally generated requirements for transport in a timely manner;[1] and the relative sensitivity of helicopter operations to adverse conditions of weather and visibility. Related factors

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1. The helicopter possesses relatively high speed capabilities, and technically it could reach any point in the Delta within a few minutes from a few central locations. However, administrative delays in dispatching and marshaling greatly increase the time required to respond to needs for transport or helicopter support at particular locations.

include the general high-cost characteristics of helicopters and their lack of suitability for low-echelon employment to meet immediate or organic transport needs of small units operating within local areas.

The requirements for mobility and for improvements in mobility are a function of the Viet Cong threat and the nature of V.C. operations and a function of the manner in which the Vietnamese are attempting to deal with the Viet Cong. The study team has investigated in considerable detail not only the concepts of operations that the Vietnamese have followed up to the present but also the concepts and methods of operation that they are expecting to follow in the future. In the ensuing brief discussions, consideration is given first to the nature of Viet Cong activities and second to those aspects of Vietnamese operations in which there are potentially significant needs for improved mobility.

Nature of Viet Cong Activity in the Delta Area

The extensive areas of mangrove and other swamp forest in the Delta area offer the Viet Cong ideal refuge. The Viet Cong and the Viet Minh have been operating in the Delta for many years. Base areas have long been established in the U Minh forest and in the mangrove forests along the coasts of the Ca Mau Peninsula. These base areas have been built up over time as a steady flow of men and material has been brought into the Delta area from North Vietnam through Laos and Cambodia. The movement of men and supplies south from North Vietnam has been principally along the so-called Ho Chi Minh trail and into the Delta from several directions.

The buildup of supplies and the establishment of V.C. infrastructure has proceeded to the point where, today, large portions of each Delta province are under V.C. control. The ARVN defend and control major towns and key areas in each province, but much of the countryside is under V.C. domination. The longer the delay in effectively controlling and clearing the V.C. from these areas, the more chance the V.C. will have to indoctrinate the people.

Inasmuch as the viability of the Viet Cong organization in South Vietnam is dependent on the V.C.'s deriving continued support from the local population, one of the major overall goals of the V.C. is to undermine the programs of the South Vietnamese government aimed at separating the V.C. from the population in general. As means of countering the government's pacification plan, the V.C. employ persuasion, threats of violence, and actual violence in dealing with the local populace and particularly with village leaders. The areas not actively defended by the ARVN are easy targets for the V.C. Hence, over a long period of time the V.C. have employed recognized guerrilla methods to gain effective control of a large portion of the territory in the Delta.

In general, the tactics employed by the Viet Cong today do not differ materially from those of the Viet Minh in the early stages of their war against the French or from those of other Communist guerrilla forces in Malaysia and the Philippines. Typically, the guerrilla lives with the people and derives protection and support from the people. The guerrilla typically does not hold terrain in an absolute sense; yet he does have strong areas in which he maintains clandestine headquarters, hospitals, communications centers, logistic bases, and training areas. The Viet Cong, for example, clearly dominate the population in the aforementioned areas of the Mekong Delta and elsewhere in South Vietnam, and they move with relative freedom in these areas.

The V.C. are armed as light infantry. They operate primarily at night in small units--occasionally they operate in battalion-size units. In effect, they have good mobility. Because the V.C. are essentially omnipresent in South Vietnam, the threat posed is equivalent to that afforded by near-unlimited mobility in that they can and do strike virtually anywhere and at several widely separated places simultaneously. To be sure, the individual V.C. or V.C. unit cannot move from place to place any faster than they can walk or navigate by sampan, but their geographic dispersion within every province and district of the country provides them with this ability to engage in offensive action in unexpected places and in several places at once. A resultant Viet Cong military tactic particularly crucial to the problem of mobility is the ambush of ARVN (or other military) forces moving on a road or canal. The ARVN force is typically lured into the ambush by a diversionary V.C. attack on a post or village. The V.C. will directly attack ARVN units when they have clear numerical superiority and tactical advantage, but tend to postpone action or withdraw when they find they do not have the advantage.

South Vietnamese Counterinsurgent Operations

Government forces have demonstrated that they have the ability to move anywhere in South Vietnam if they do so with sufficient force. One of the reasons for this freedom of movement may be that the V.C. choose tactically not to fight against superior forces but rather to disappear into the surrounding countryside. Despite the physical ability of the ARVN to move with relative freedom with an adequate-size force, such movements afford limited advantage because they are frequently known to the V.C. in advance, they are slow, and they are highly channelized because of limited lines of communication and adverse environmental conditions, as indicated.

The ARVN is further hampered in tactical operations because, as noted above, the V.C. have developed certain areas within the country which serve as relatively secure bases. Such bases may be located anywhere, but are usually established in remote areas where some natural terrain feature affords added protection. This type of protection is usually achieved by choosing base locations having a very limited number of access routes, thus allowing the V.C. to be forewarned of an attack and giving them time to disperse. Also, the area chosen is usually such that the V.C. are able to disperse into innumerable hiding places, and the tactical movement of Vietnamese forces attempting to pursue and destroy the V.C. thus becomes extremely difficult. Clearly, then, great importance must be attached to the ability of the ARVN units to move quickly and with a minimum preparation to achieve surprise and, in turn, good results in clearing operations.

To a large extent, the government has chosen or found it necessary to garrison its major forces in a few centralized locations. This approach affords relative flexibility for employment of forces as and where needed for specific operations, but at the same time it establishes a requirement for the capability to move quickly over relatively long distances in conducting certain types of operations against the V.C. Increasing attention is being given to a greater dispersion of ARVN units as part of the general pacification plan. However, because of the extent of V.C. control within the Delta, it is not possible for the ARVN to pacify or effectively occupy or control all parts of the Delta at the same time. There is a requirement, therefore, to maintain the capability to respond over fairly long distances to attacks against remote posts and towns outside specific pacification zones.

One of the frustrating aspects of operations against the V.C. is the difficulty of establishing contact with the insurgents. When an insurgent force attacks a post or village, that force is in contact and its specific location is known. Tactically, then, it is highly advantageous to try to exploit this contact by immediate deployment and concentration of superior forces. Although this type of action is somewhat defensive in nature, the effective execution of such a maneuver can result in success in terms of enemy casualties. The mobility required to conduct effective deployments of this type over distances of more than a few kilometers can probably be provided only by the helicopter. Thus, the helicopter has been and should continue to be the primary means of meeting such needs for movement.

It was observed earlier that there are certain limitations on the tactical use of the helicopter. In the context of this discussion, the critical limitations relate to whether the helicopter can be made available to meet the requirements for <u>immediate</u> deployment of a relief force. The difference between a successful and an unsuccessful response to a V.C.

attack against a particular target is often simply a matter of how quickly the deployment can be made. Frequently, helicopter deployments are considerably delayed because of other commitments for these aircraft, because of the need to marshal the aircraft from many different locations, and because of helicopter sensitivity to weather and visibility conditions.

Requirements for Improved Capabilities for Off-Road Movements in Local Areas

There has been considerable recognition of the need for some change in the general approach to dealing with the V.C., based on the realization that the types of military operations being conducted are not as effective as they could or should be. One result of this recognition has been the development of a general plan for pacification, under which much emphasis is to be placed on the use of many simultaneous small-unit operations to clear particular areas of organized V.C. units and on the development of means of thereafter maintaining the long-term security of the particular areas under "pacification." The approach of the National Pacification Plan, to be carried out simultaneously within individual provinces, involves political, economic, and social development programs as well as programs for dealing directly with military and security matters. However, the concern of this study has been most directly with the possible implications of pacification plans relative to the need for mobility in various types of military units.

In a forthcoming manual on pacification being prepared by MAC-V J-3, it is argued that the large-scale hammer-and-anvil tactics employed to clear main-force elements of V.C. from an area have not worked well and should be replaced with the "area saturation" technique of employing smaller units in continuing operations. The hammer-and-anvil tactic seems to work well when a large concentration of V.C. can be located. Even in such situations, however, it has the shortcoming of being only a short-term operation into V.C. country. Whatever numbers of V.C. are missed by the ARVN thrust are able to continue activities as before. In addition, use of the hammer-and-anvil technique generally requires that a large ARVN force be assembled and transported to the objective area. Maintaining the security of large operations such as these is most difficult, if not impossible, in view of the advanced planning that is necessary.

The conventional large-scale sweep employing the hammer-and-anvil tactics is often based on intelligence reports that fix an enemy unit in a particular place at a specific time. This intelligence has often proved to be unreliable or untimely, and the troops arrive at the specific location only to find that the V.C. have vanished. It is recognized that one of the most difficult problems in the counterinsurgency environment is that of locating the enemy. Hence, continuing small unit-patrol operations is probably the most effective means of locating the enemy within particular areas.

In overall terms, pacification operations should be considered as offensive operations against the V.C. in a specific political area, such as a district or a portion of a province. In general, pacification is divided into three major tasks: clearing, securing, and developing. These tasks differ from the concepts of "clear and hold" operations, under which it would be assumed that the ARVN would perform the clear and hold operation largely by themselves. Under the pacification scheme, popular military and local police capabilities will be developed to maintain the security of the area for further development, thus eventually releasing the ARVN to repeat the clearing process in an adjoining area.

The first pacification task of the ARVN is to clear an area of V.C. main-force units by area saturation and constant small-unit operations in a specific area. The saturation technique involves deploying a force, such as a battalion, into V.C.-held country and assigning to each company of the battalion an area of responsibility, with the size of the area depending on the nature of the terrain. The saturation tactic of employing constant day and night platoon-size patrols to clear each area of responsibility is intended to result either in the capture of the V.C. in the area or in V.C. abandonment of the area. The search is carried on with aerial reconnaissance and artillery support. If a sizable enemy force were located by the platoon patrols, immediate reinforcements from battalion would be directed to the scene to engage that force.

The platoons are expected to depend on foot mobility while on patrol, and little use would be made of vehicles. However, it is necessary for the reinforcing elements to be able to move quickly to engage the V.C. before contact is lost. While helicopters might be suitable for this purpose, if available, the distance over which deployment would be required is short and the high speed of the helicopter is probably not required. Rather, the critical concern is the immediacy with which the reinforcing elements can respond and move over a relatively short distance. It is clear that a vehicle offering good off-road mobility would be advantageous in this operation if it could be made available without delay. Movements of perhaps 10 to 20 kilometers are probably all that are required for the immediate response situation described here. It would not be expected that a vehicle suitable for troop movements in this type of situation would be employed basically as a tank in the same way that the M-113 is often employed in present operations. Rather, the requirement would be for a vehicle that can function well off-road and is available continually in the local area to provide immediate troop lift as needed. There appears to be little requirement for an armored personnel carrier per se to perform this basic transport function.

In the second pacification task, or the process of securing the area, popular forces are trained to defend towns, villages, and bridges, while certain ARVN forces remain for pacification zone security. The main force of ARVN leaves the area to execute clearing operations in adjacent areas or elsewhere. Those ARVN elements that remain are required to support popular force posts, and these troops must be sufficiently mobile to provide immediate aid anywhere within the local pacification area. In such a situation, both popular forces and ARVN forces would need the same type of capability for movement as would the ARVN forces engaged in the clearing phase. Again, this need could be met by having a small number of good off-road vehicles available in the local pacification area at all times.

During the securing and development phases of the pacification, which may span many months, there is also a need to meet the mobility requirements of the security forces that at some point replace the ARVN units. Again, these requirements can be met by the types of equipment indicated above. The major consideration here is that pacification may be under way in widely dispersed locales, and there would thus be a long-term, continuing need for such means of movement to be readily available within the various pacification areas--else the security of the populace could not be ensured.

Requirements for Improved Capabilities for Movement on Waterways

Improved Craft for Tactical Lift. The River Assault Groups (RAG's) perform essential functions in providing lift in support of the tactical (or administrative) moves of ARVN units, particularly along the major rivers. Operations have frequently been conducted on major canals throughout the Delta, but the threat or likelihood of ambush is much greater in canal operations than on the principal rivers, and heavy losses have been incurred.

The Viet Cong have extensive control of the stream and canal banks in the Delta, and the RAG boats are very vulnerable to attack by recoilless rifle fire directed at close range from the banks. Additionally, mines are planted in these relatively narrow waterways and then fired electrically and selectively from the bank against specific targets in a convoy. Other than through control of the banks, there is little that can be done to reduce the extreme hazards attending RAG operations on these smaller waterways on which there is much less room for maneuver than on the major rivers. The general threat on the canals and lesser streams is such that redesigning the RAG boats to reduce their draft--and thus to make navigation of more shallow waterways technically feasible--would not substantially increase the length of waterway over which the boats would operate--unless, that is, additional efforts were made to control the banks. Many waterways that could now be navigated normally are not entered or utilized because of the ambush problems. To avoid an ambush, escorting troops sometimes move along the banks, but such movements are extremely slow and not suitable for rapid deployments.

The assigned mission of a River Assault Group (RAG) is to lift a battalion of ARVN (groups are located at several bases in the Delta area). Such groups operate with slow-speed LCM-6 craft and with small patrol vessels, called STCAN's. These RAG boats are armed with 30-caliber and 50-caliber machine guns and 20-mm and 40-mm guns. Indirect fire capability is provided by an 81-mm mortar mounted in the fire support LCM-6, called the Monitor. The armor plating deemed necessary on the LCM-type craft by the Vietnamese has reduced the speed of these boats to approximately 8 knots. The armament aboard these craft is intended primarily for the defense of the force while under way and not for gunfire support of the landing force. There appears to be little requirement for the RAG's to provide fire support for the tactical unit making the assault, since fire support can almost always be better provided by ARVN artillery firing from semifixed locations. Most of the Delta area is covered by artillery located in ARVN-controlled centers.

For operations along the major rivers, it would be highly advantageous if the RAG boats were capable of speeds somewhat greater than 8 knots. At that speed the RAG boats are handicapped in providing expeditious movement, particularly since 5- to 6-knot currents are quite common. Such slow boat speeds are not satisfactory for logistic movements in the face of adverse currents and are completely inadequate for troop lifts in tactical operations. In fact, RAG capabilities for lifting the M-113 troops along the major rivers are presently even less satisfactory than the foregoing, because primary dependence is currently being placed on the 6-knot LCU (not normally part of the RAG) in such operations. The 10- to 12-knot LCM-8 is to be introduced in-country shortly as a replacement for the LCU, and will offer some advantages if its speed is not cut way down by heavy armoring and arming.

Improved Craft for Patrol Operations. For the Delta to be successfully pacified, it will be necessary to reduce the V.C. freedom of movement from one sector to another within the Delta. The infiltration routes used by the V.C. require many river crossings as well as movements along rivers and other waterways. While a secondary mission of the RAG's is to patrol the rivers, this patrolling is at present both intermittent and ineffective.

As noted, each RAG has a number of small craft called STCAN's, which are sometimes used as patrol craft. However, these boats are usually employed with the RAG when it is involved in a troop lift. The speed of the STCAN's is only a little better than that of the LCM's. It appears that the craft used for regular patrol operations on the major rivers should have significantly faster speed capabilities than do those presently available to the river forces. If rigorous patrolling is to be established on these rivers and their major tributaries to prevent their free use by the V.C., a substantial number of patrol craft will be required. These craft need not be large nor of extremely shallow draft, but they should be fast enough to overcome the currents and to overtake expeditiously the river craft typically used by the V.C. The V.C. often use the sampan, frequently as powered by a long-shaft outboard to attain speeds of 10 to 12 knots. The currents near the mouths of the rivers can be as fast as 6 to 7 knots. Therefore, the speed capability of a patrol craft should be, at the very minimum, 15 knots. A speed capability of 20 to 25 knots would be highly advantageous.

Along with faster patrol craft for use on major rivers, consideration should be given to making available to river patrol forces a surveillance system employing radar and perhaps sonar for detection of V.C. movements at night and during periods of restricted visibility. Of course, strict curfews on civilian movements at night would have to be established as part of this overall scheme. In the past, Sea Force Ships equipped with radar have been temporarily used with good results for surveillance at the mouth of the Bassac. Radar gear that would provide detection capabilities adequate for the river surveillance task and that would be sufficiently lightweight and compact for use on small patrol vessels could be made available in the immediate time period.

There appears to be a requirement to maintain more effective control over V.C. movements across or along the canals and lesser streams. Shallow-draft indigenous craft, such as the relatively slow-speed sampans, offer considerable potential for patrolling operations on small waterways within specified areas. The shallow-draft, higher-speed Dong Nai Boat is also available, but is not frequently or intensively employed in such operations, perhaps because it is not highly maneuverable. A small shallow-draft craft with higher speed than the sampan and better maneuverability than the Dong Nai Boat could be advantageously employed in patrol operations. The availability of such a craft for night patrolling may well be of particular importance. Silent or near-silent motors and propulsion systems for small patrol craft would offer obvious advantages in such operations.

V SELECTION OF SUITABLE PLATFORMS

In the preceding sections, environmental conditions in the Delta area have been characterized with respect to factors critical to the performance potentials of water craft and off-road vehicles, and potential requirements for improved mobility for various types of military operations have been identified. It remains in this section to consider potential platforms that might afford improved mobility and to select those platforms that could be made available to meet specified potential requirements for improved mobility in the immediate time period.

In general, mobility may be improved in essentially three ways, namely (1) by the provision of a greater number of water craft or vehicles for use in a particular area; (2) through the introduction of platforms affording both greater freedom from dependence on prescribed lines of movement and improved capability for movement under the adverse conditions found in the Delta area; and (3) through the introduction of platforms with improved speed capability. Assessment of various alternative platforms in terms of the latter two factors will indicate the particular craft and vehicles that represent the better means of improving mobility for particular needs. Numerous designs of both existing and proposed platforms are available for use in these assessments.

Types of Platforms To Be Selected

On the basis of the discussions in the foregoing sections, the conclusion is made that improved capabilities for movement or mobility in the Delta area are required principally in the deployment of small tactical units within limited geographic areas, such as a district or a province. For these units to be deployed expeditiously, there is a need to be able to make such movements immediately, without waiting for the marshaling of transport services from distant points. And there is a critical need to be able to make these movements off-road and off-waterway because of the ever-present ambush problem. Vehicles potentially suitable for employment in this type of role will be identified in the following pages.

The general conclusion is also made that improved capabilties for waterborne movement are required on the major waterways to make possible regular, intensive patrolling to cut down the freedom of V.C. movement into and within the Delta. Craft presently available in Vietnam for major river patrols do not have adequate speed capabilities. Additionally, craft with greater speeds than those afforded by craft now available to the RAG's need to be introduced for employment in support of tactical operations along these major rivers. Capabilities for effective patrol operations on the smaller waterways could also be enhanced if small-craft types having more suitable characteristics than do the smaller boats now available in Vietnam could be introduced and employed to disrupt and control V.C. movement or use of these smaller waterways within specified areas.

General Approach to Evaluation of Platform Performance

In an evaluation of platform performance, many particular factors should be taken into account, and it is useful to consider these in general at the outset. Thus, this brief introductory discussion will be concerned first with certain factors related specifically to mobility on waterways, then with certain other factors bearing specifically on mobility on land, and finally with certain additional factors not directly related to mobility.

Platform Mobility on Waterways

Among the principal factors to be weighed in evaluating the potential suitability of particular water craft and amphibians for operation on waterways in the Delta is the ability to operate in shallow water. As indicated in Section III, many of the streams and canals making up the dense network of waterways in the Delta have very limited depths. Therefore, the ability of a platform to operate in shallow water is a critical concern, particularly in the case of craft or platforms suitable for local waterway patrol activity.

For those craft that would be employed primarily on the major rivers and larger canals, drafts of 4-1/2 to 5 feet would be acceptable. On the lesser waterways, a draft of over 2-1/2 to 3 feet would be unacceptable. The lower the draft, the greater would be the flexibility of employment; therefore, shallow draft is in all cases an important criterion.

The speed capability of a platform is another important factor to consider. Since some waterways are characterized by strong currents, the need for certain minimum speed capabilities to overcome these currents and to provide a reasonable rate of movement is obvious. For tactical support operations on the major rivers, speeds of at least 15 knots--and preferably 20 knots--would be highly advantageous. Moreover, for certain types of missions on the waterways, a capacity for even higher speeds may be quite important or advantageous, if achievable at reasonable costs. This potential would relate particularly to craft for patrol activities.

The maneuverability of a platform is important to consider in light of the frequency with which obstacles to navigation may be encountered, and, clearly, successful avoidance of such obstacles may depend on the ability to execute a sudden change of course. This requirement would be particularly significant at the higher operating speeds and on the lesser canals and waterways.

The ability to move a craft under low bridges is still another consideration for waterbound craft to be employed on the smaller canals and streams in the Delta area. Many bridges are found over these smaller waterways, and height above the waterline may be vital to mobility, particularly during the high-water periods. Heights greater than that of present LCVP would clearly be disadvantageous on these waterways.

Vehicle Mobility on Land

Several factors are critical to the assessment of the overland mobility of amphibious and non-amphibious vehicles considered for use in the Delta. One of these is the ability to develop sufficient traction, regardless of engine power, to move over the weak soils that characterize most of the Delta area. This ability may be assessed relative to the general state of the ground in the Delta and the probable strengths of these soils, as measured in terms of probable soil cone index values. The soils in the Delta area are predominantly silt and muck. In the wet season, a median cone index value of no more than 60 is probably characteristic of this soil under favorable conditions of drainage. A minimum cone index value, or the soil strength required for a vehicle to be mobile, may be derived by developing a computed mobility index for the vehicle. The latter index is based on certain design characteristics of the vehicle itself. Conditions generally are such that a value representing good performance over extremely weak soils (equivalent perhaps to soil cone index values in the 30-45 range) would be quite important.

Any vehicle satisfying the requirements for off-road mobility in the Delta area clearly must provide sufficient engine power to move over difficult terrain (over obstacles) and to overcome the resistance encountered in moving through heavy mud. A particular vehicle may have the ability to develop sufficient traction under the conditions noted above (on the basis of track or wheel configuration, flotation, and weight), but may lack the necessary engine power.

Another factor that should be considered in evaluating vehicles is the ability to maneuver around difficult obstacles and, where such obstacles cannot be avoided, to retain the stability necessary to cross them.[1]

1. The general gradeability of a vehicle is not important in the Mekong Delta because of the very flat character of the terrain, as indicated in Section II

Moreover, the vehicle should have the strength to withstand the dynamic forces that occur in operating over rough ground and in crossing obstacles. Various design features, such as type of vehicle (tracked, wheeled, or other), wheelbase or vehicle length, vehicle width, center of gravity, track or tire size, number of tires, suspension system, vehicle weight, and type of steering all influence obstacle-crossing capability. The ultimate selection of the most suitable vehicles therefore requires a detailed comparison of obstacle performance.

Speed capability is, of course, a factor of importance in evaluating vehicles. Attaining improved vehicular speeds over land may well be important, but it should be recognized that, in the Delta environment, high off-road speeds will not be attained with tracked or wheeled vehicles. Only the ground effect machine and perhaps other new vehicle concepts, such as the Airboat, would offer significant increases in off-road speed capabilities.

Vegetation, stream banks, and microvariations in surface conditions constitute natural features that impede vehicle movement, as has been indicated. Most critical, however, are the man-made obstacles, such as drainage ditches, canal banks, rice paddy dikes, and raised roadbeds. A particularly difficult obstacle for an amphibian vehicle is often the bank along a waterway. Generally, exiting a waterway is more difficult than entering, and amphibians have difficulty in exiting waterways if the bank slopes are steep or soft either above or below the waterline. The slope below the waterline is especially critical for a floating amphibian. For such vehicles, the tracks or wheels do not provide sufficient traction or purchase on the slope because they are working largely against the water. Thus, there may not be enough tractive force to move the vehicle forward and up the incline. Because steep or soft slopes prevail along the waterway banks in the Delta area, it is very important to consider the comparative ability of alternative vehicles to exit waterways under such conditions. The problem of exiting a waterway with steep banks or banks with soft soil is made even more difficult by the presence of restrictive vegetation on the banks.

Factors Other Than Mobility

Several factors other than those related directly to mobility need to be considered in an overall evaluation of either water craft or vehicles. One of these is simplicity of design. This factor is important in that, generally, if the design is simple, operator-training requirements tend to be simplified and maintenance problems are held to a minimum. For the more complicated platforms, maintenance personnel need to be more highly trained and spare parts inventories must be larger. It is highly desirable that a vehicle or craft selected for use in the Delta area be so designed that defective components can be replaced in the field without moving the equipment to a repair shop. This feature permits a higher rate of platform availability, reduces the requirement for including skilled mechanics in field units, and minimizes the number of spare parts to be inventoried in the field. It is also in the interests of economy that any family of platforms have a high degree of interchangeability of repair parts and components.

It is also necessary that a basic distinction be made between presently available platforms and proposed platforms. In this analysis, consideration has been given primarily to presently available platforms and to a lesser extent to a number of proposed platform concepts or designs. Considerable difficulty is involved in properly classifying design alternatives as presently available or proposed, because much judgment is involved in determining whether certain platforms presently under development have been sufficiently tested to provide a basis for a decision to produce in quantity in the immediate time period. There are numerous vehicle concepts under development, but thus far only test platforms have been built. In most cases, designs to meet practical operational requirements have not been brought to the point of prototype construction or even detailed formulation.

Considered from another point of view, presently available and proposed designs can be distinguished on the basis of the amount of time required to obtain delivery of a certain number of units. Where platforms are available from an inventory, the time required would be nominal. Where no such inventory exists but a producing plant can deliver units promptly from current production, some limited period of time would be needed to obtain a given number. If a new production line would have to be established, however, many months might be required for tooling and production. Thus, the distinction between designs presently available and designs proposed rests upon the specification of certain time periods within which vehicles or small craft can be delivered.

With the foregoing points taken into consideration, it appears useful to regard as "presently available platforms" those which can be delivered in quantity within a six-month period and to categorize as "proposed platforms" those designs for which prototype models have not yet been thoroughly tested. Moreover, it seems evident that an additional step may be required between the testing of a prototype and a decision to introduce a particular vehicle into South Vietnam. This step would be the procurement of a limited number of operational designs for field testing and operational employment outside Vietnam. This step would appear to be particularly important in considering radically new vehicle concepts.

Preliminary Selection of Platforms Suitable for the Delta Environment

It is useful to consider briefly a general classification, or spectrum, of platform concepts, as presented in Table VI. Listed on the left side of the chart are land-bound vehicles--both tracked and wheeled types--which have no more than a fording capability in water. On the right side of the chart are water-bound craft, including conventional displacement planing hulls and hydrofoil and hydrokeel concepts. Listed between these two general categories are the amphibians.

Some of the amphibians shown in the table are vehicles that are primarily operable on land but afford some swimming capability. Included among these are certain rather than conventional tracked and wheeled vehicles, as well as Airoll and PATA vehicles. Certain other amphibians may be classified as vehicles primarily operable on water but with some ability to operate on land. This category includes certain tracked and wheeled vehicles, plus the Marsh Screw and the Airboat, as shown in the right-hand column under amphibians.

A broad range of existing or potential platform concepts has thus been considered (see Appendixes B through E for summary listings of the basic characteristics of a wide range of platform concepts). For each concept considered, suitability has been assessed with respect to the Delta environment and, in the final analysis, attention has been given to the potential availability of a particular type of vehicle for immediate adoption without extensive further development or testing.

The true amphibians, as shown in the center of the chart, are best represented by the Ground Effect Machine (GEM), or air cushion vehicle (ACV) as it is also called. In technological development, the GEM has advanced greatly in recent years, particularly with the employment of flexible skirts or trunks to minimize power requirements or give greater obstacle-crossing capabilities. In many ways, the GEM holds much prospect. However, it is not yet available for immediate employment in significant numbers, and the potential operational concepts that it might make feasible have not been fully explored. Efforts should be made to develop prototype vehicles for possible specific types of requirements and to have these vehicles undergo field testing by operational units, leading to the formulation of concepts of employment.

Early in the study certain vehicles were excluded from further detailed consideration on the basis of their being clearly unsuited to the particular characteristics of the Delta environment. Non-amphibious or land-bound vehicles were thus excluded from further study on the basis that off-road mobility, rather than on-road mobility, should be the primary concern. The

Table VI

GENERAL CLASSIFICATION, OR SPECTRUM, OF PLATFORM CONCEPTS CONSIDERED

	Amphibians			
Land-Bound Vehicles	Vehicles Primarily Operable on Land But Can Swim	True Amphibians	Vehicles Primarily Operable on Water But Can Operate On Land	Water Craft
Tracked	Tracked	GEM	Tracked	Conventional
Wheeled	Wheeled		Wheeled	Hydrofoil
	Airoll		Marsh Screw	Hydrokeel
	PATA		Airboat	

Source: Stanford Research Institute.

great density of the waterways in the Delta and the particular characteristics of these waterways, as previously detailed, impose a clear requirement that vehicles have a swimming capability rather than simply a stream-fording capability.

A second category of vehicles excluded from detailed consideration in this study comprises wheeled amphibians. It has been amply shown that wheeled vehicles are poorly suited to the severe surface conditions found in the Mekong Delta area of South Vietnam. Specifically, the prevalence of extremely weak soil conditions during much of the year and the widespread occurrence of the types of obstacles that pose exceptional difficulties for wheeled vehicles ruled out the further consideration of these amphibians within the specific objectives of this present study.

Some attempts have been made to overcome the relatively poor mobility on weak soils of such standard wheeled vehicles as the M-35 2-1/2 ton truck by designing vehicles with much larger tires. Moreover, attempts have been made to improve the mobility of such vehicles as the Dodge Power Wagon Truck by mounting the relatively large terra tires on the vehicle, and the use of large tires does improve the ability of such a vehicle to traverse comparatively soft soils. However, for the types of situations found in the Delta area, such a vehicle could provide performance comparable to that represented by tracked vehicles of equivalent capacity only by employing tires so large[1] that the vehicle itself would be unduly large and awkward. Thus, in this present study, attention was focused only on tracked amphibians.

A third general exclusion of vehicles applies to the so-called surfing amphibians, which are designed essentially for ship-to-shore operations in which the ability to operate through the surf is critical. Tracked amphibians of this type (in the fourth column of Table VI) incorporate design features that make them poorly suited for overland operations. For example, the LVTP-5 and LVTP-6 surfing amphibians are extremely heavy (see Appendix E) and, in both size and configuration, are far from satisfactory for traversing the terrain of the Delta.

Selection of Water Craft To Meet Potential Requirements

Numerous designs of existing and proposed water craft types are available for assessment in considering ways of meeting the general requirements for faster boats for RAG employment in support of tactical operations along the major rivers and for patrol operations along both major and minor waterways.

The basic characteristics of a large number of watercraft (listed in Appendixes B and C) were examined to gain an appreciation of feasible relationships among sizes, speeds, and drafts. A selected number of craft, ranked by speed capability, are shown in Table VII. Included in this list of 14 craft are five types that are presently used by military forces in the Mekong Delta. Among these five craft, the designations LCM-6, LCVP, and LCU are immediately recognized as U.S. Navy nomenclature. The craft so designated in South Vietnam, however, are quite dissimilar to their U.S. Navy counterparts in that they are outfitted for on-board living and have armor plate on the sides. The actual speed of these craft is generally not more than 8 knots. The STCAN is a French-built craft somewhat similar in size to the LCVP. It is a relatively shallow-draft,

1. Employing a relatively large number of smaller tires will also permit comparatively good soft-soil trafficability, but excessive vehicle complexity and other problems may result.

Table VII

SPEED CAPABILITIES AND DRAFT OF SELECTED WATER CRAFT

Craft	Maximum Speed (knots)	Draft Loaded (feet)
Airboat (17')	52	1.0
Patrol Cruiser (hydrokeel)	48	2.2
Polyhedral	35	4.0
Rescue Boat (46')	33	3.0
Boston Whaler (16.7')	33	2.0
Klong Boat (MRDC-4)	27	2.0
Picket Boat	25	3.3
Dong Nai Boat*	17	2.0
River Patrol Craft (BUSHIPS)	15	4.5
LCM-8	12	5.2
LCM-6*	11	4.6
LCVP*	10	3.8
STCAN*	10	2.5
LCU*	8	6.0

* Presently used in the Mekong Delta.

Source: Stanford Research Institute.

steel hull, V-bottom boat with very good maneuverability. It is quite slow, as noted earlier. The Dong Nai Boat is a small plastic craft propelled either by outboard motor or by paddle. As the organization of the table suggests, one of the principal purposes here is to consider types of craft that could offer improved speed capabilities.

The Airboat ranks first among the listed craft in terms of speed potential. It has a maximum speed of over 50 knots under favorable conditions. This boat has a thin plastic shell, with a large airscrew and engine mounted on the rear. Airboats probably could be practically configured to provide a platform suitable for certain limited patrol and pursuit-type activities. In late 1964, a number of Airboats were sent to Vietnam for testing by ACTIV. In view of this development, further consideration of the Airboat should of course await the results of the testing in that particular environmental situation and the formulation of possible concepts of employment.

The Patrol Cruiser, which is based on the hydrokeel principle, also can attain very high speeds, as demonstrated by an experimental boat that has been successfully operated at such speeds. A boat of this type uses a high-volume blower to force low-pressure air under the hull. The sides of the hull project below the flat bottom to form keels which, along with flaps installed at the bow, help retain a partial air cushion, or pressure differential, below the craft. The hydrokeel hull rides on the resulting air as it skims over the water surface, thus reducing friction and making possible much greater speeds than those attained by conventional craft. Boats of this type could be employed both as troop carriers and as patrol craft on the major rivers, if such high-speed capabilities are in fact required.

Although not included in the table, hydrofoil craft can readily provide speeds of from 35 to 50 knots or more. Thus, the hydrofoil boats have speed capabilities generally comparable with those of the Airboat and the hydrokeel types. The hydrofoil craft might also have considerable potential for use on the major rivers, especially as patrol vessels, and if their full speed capabilities are required. Hydrofoil amphibians would not appear to be suitable for overland operations and general employment in the Delta area because of their size and complexity and perhaps because of cost considerations.

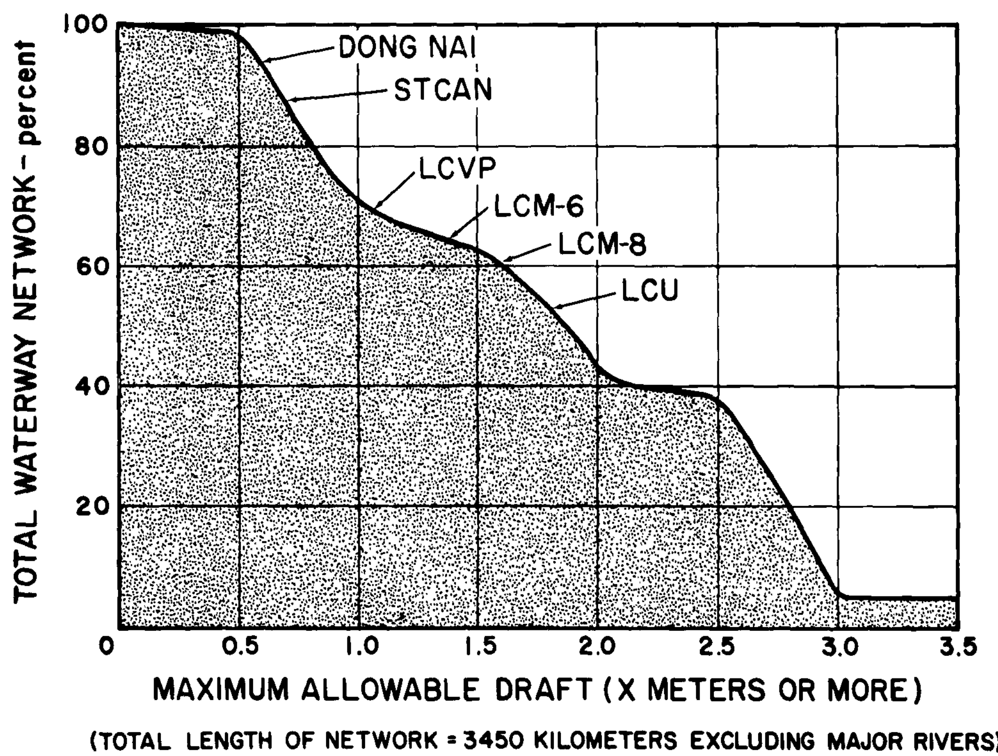
The Polyhedral, Rescue, and Picket boats represent rather conventional V-bottom planing hull designs, with installed horsepower sufficient to permit speeds of 35, 33, and 25 knots, respectively. All three of these craft provide substantially greater speeds than those afforded by present craft and by the new-design BUSHIPS River Patrol Craft (RPC) currently being introduced in very limited quantities. The RPC designed by BUSHIPS for operations in the Delta area of South Vietnam is rather slow, offering only very modest improvements over the speed of craft presently in-country. It will, however, offer the potential for employment both as a patrol craft and as a troop carrier.

The small Boston Whaler is a flat-bottom, blunt-nose fiber glass boat, which is normally equipped with an outboard motor. It offers good shallow-draft capabilities and can be operated at speeds up to 30 knots or so, depending on whether a conventional or a long-shaft outboard motor is used. The long-shaft outboard could be used on waterways where extremely shallow depths and considerable vegetation would be expected to be encountered. This craft is therefore potentially suited for small waterway patrol-type activities. Another small boat that appears very attractive for small waterway requirements is the Klong Boat, built in Thailand under ARPA sponsorship. This craft also may be propelled by either a conventional outboard motor or a long-shaft motor. As indicated, this flexibility is advantageous for operations in shallow water or in water containing much vegetation. This boat is capable of operating at 27 knots or more with a conventional shaft, and it is particularly maneuverable, a characteristic enabling it to offer significant advantages over the Dong Nai Boat.

As suggested earlier, present plans call for the introduction of some LCM-8's into the River Assault Groups in the Delta in the near future. It will be noted in Table VII that the LCM-8 will provide only modest improvements over existing craft in speed capability, and even this gain could be lost if the Vietnamese heavily arm and armor the LCM-8. However, the availability of the LCM-8 (assuming that design speed capabilities are retained) will be of considerable advantage both for troop lift and for deployment of M-113's along the major rivers.

Table VII also shows the draft for each of the listed craft, assuming that rated loads are being carried. Drafts range from 1 foot for the Airboat to 6 feet for the LCU. The Boston Whaler, Klong, and Dong Nai boats have about the same draft--about 2 feet with a conventional outboard motor or 1 foot with a long-shaft motor. The Dong Nai, currently available in-country, is not employed a great deal, reportedly because of problems related to vulnerability of personnel, maneuverability, and noise. Among these several boats, relatively greater maneuverability could be achieved with use of the Klong Boat or the Boston Whaler, and perhaps noise reduction could be attained on the Dong Nai itself with use of different motors. With none of these boats, however, could much improvement be expected in vulnerability.

The potential importance of shallow draft as a required characteristic of craft suitable for use in the canals and off the major rivers of the Delta becomes evident when the draft limitations of various boats are related to the extent to which the use of the waterways is controlled by specific depths. In Fig. 2, such relationships are seen. For any given craft, the horizontal axis shows the maximum allowable draft, measured in meters, while the vertical axis shows the percentage of the total network



Source: Stanford Research Institute.

Fig. 2 NAVIGABLE WATERWAYS - LOW WATER ALLOWABLE DRAFT
SOUTH VIETNAM - MEKONG DELTA AREA

of navigable waterways in the Delta (excluding major rivers) that can accommodate that particular craft. The curve represents the cumulative percentage of network length that can accommodate craft of various draft. Thus, the Dong Nai Boat, with a draft of 0.6 meter (2 feet), can be accommodated in 95 percent of the network. On the other hand, the LCU, with a draft of 1.8 meters (6 feet), can be accommodated in only 52 percent of the total network. The LCU is, of course, completely unsuited to employment on the canals because of its size (it is shown for reference only). Four other craft with drafts intermediate between those of the Dong Nai and the LCU are shown on the chart as examples. Clearly, the extent of the waterways in the Delta that can potentially be used for inland waterway operations is strongly influenced by the draft of the water craft in point.

In addition to the major waterways represented in this chart, there are, as illustrated in the earlier discussion of the environmental situation, extensive minor waterways which are not generally regarded as navigable but which can be used by sampans and other small craft. The Dong Nai Boat and the ubiquitous sampan, either paddled or powered by long-shaft motor, are presently employed on these minor streams and canals. The Klong Boat and Boston Whaler are also suitable for similar types of use. Because of their configurations, these latter two craft are capable of better speeds than the Dong Nai Boat and the ordinary sampan.

With respect to potential requirements for water craft, then, it has been found that significant improvements in capabilities for selected waterborne operations on the major and minor waterways could be readily accomplished on the basis of existing technology and with little or no delay. For troop-lift and tactical-support operations as well as patrol operations on the major rivers, craft such as the BUSHIPS 15-knot RPC would offer very modest, but perhaps worthwhile, improvements. More significant improvements could be achieved if the newly designed RPC had been given a 20- or 25-knot capability. Perhaps in subsequent construction (following completion of the very limited number presently under construction), modifications could be made to provide somewhat greater speed. The assessment of the characteristics of various existing craft, such as the 30-knot Rescue Boat (which might have a direct potential, for example, as a patrol craft), indicate that boats of speeds up to 30 knots could be made available if the advantages of greater speeds were found to warrant the greater costs that would be incurred.

Improved capabilities for local patrolling and local population-control activities on lesser waterways can be achieved with use of the highly maneuverable, high-speed, shallow-draft Klong Boat. Designed under ARPA auspices in Thailand, such a craft seemingly could be manufactured in-country if appropriate.

Selection of Off-Road Vehicles To Meet Potential Requirements

Various types of off-road vehicles having amphibious capabilities have been considered with respect to the potential requirements for an effective off-road vehicle to be permanently deployed at key locations throughout the Delta area to provide personnel transport within fairly small areas. The characteristics of a considerable number of vehicle types are given in Appendixes D and E. Several categories of amphibious vehicles are shown in Table VIII, each of which represents a different design concept. As far as possible, the general speed capabilities or characteristics of the vehicles so categorized are indicated for both water and overland operation.

Table VIII

SPEED CAPABILITIES OF SELECTED OFF-ROAD VEHICLES
(Miles per Hour)

Vehicle	Water Speed	Overland Speed: Rice Paddy	Overland Speed: Marsh
Tracked vehicle[a]	2.1 - 4.5	Up to 30[b]	Up to 30[b]
Airboat	60	Unknown	60[b]
Marsh Screw	7.5 - 15.0	Unknown	Unknown
Airoll/PATA	6.4	Unknown	Unknown
GEM	60 to 80	60 to 80[b]	60 to 80[b]

a. Excluding surfing amphibians.
b. Assuming highly favorable conditions.

Source: Stanford Research Institute.

The water speed of tracked vehicles (excluding surfing amphibians) is shown as 2.1 to 4.5 miles per hour. This capability is rather poor in relation to the speed ranges of the Airboat, which can achieve speeds up to 60 miles per hour, and of the GEM, which has a potential speed of 60 to 80 miles per hour. For the Airoll or PATA, water speeds are little better than those of the tracked vehicles. The water speed of the Marsh Screw, shown as 7.5 to 15 miles per hour, is significantly better than that of the tracked vehicles. As indicated earlier, wheeled vehicles, including wheeled amphibians, have been excluded from consideration in this study.

The basic "shoe-box" configuration of tracked amphibians and the Airoll and PATA vehicles, which are designed primarily for operation on land, militates strongly against the achievement of good water speeds. These vehicles are subject to a great amount of water resistance, and high speeds therefore cannot be obtained with any reasonable amount of installed horsepower. The Airboat, which skims along the water surface, encounters only slight water resistance and therefore can move at high speeds. The GEM, which operates out of physical contact with the water, encounters only air resistance and can therefore attain even high speeds.

The overland speed capacities of these various types of amphibians cannot be so readily specified because, in any given situation, the speed that can be attained is a function of the particular terrain or surface conditions. Thus, the ground environment in point must be rather precisely described. Moreover, to obtain specification of the speed capability for a given surface condition, it is necessary to test the vehicles under actual or directly comparable conditions. Nonetheless, certain meaningful observations can and should be made regarding the overland speed capacities of these off-road vehicles.

Experience with the M-113 Armored Personnel Carrier in the Mekong Delta indicates that speeds up to 30 miles per hour can be achieved in rice paddies where conditions are highly favorable--for example, where firm soil is not more than a few inches below the soil surface and where dikes are relatively low. Such speeds would be attainable over flooded paddy. In the dry season, however, the soil comprising the dikes is hard, requiring the vehicles to slow in crossing these obstacles. Experience also indicates that the M-113 can traverse certain marsh areas at about 30 miles per hour. Such speeds, of course, could be sustained only for short distances because of the necessity of stopping and then proceeding at very slow speeds in crossing the ditches of canals of any substantial size.

The Airboat has apparently been able to perform almost as effectively under favorable types of marsh conditions as it does on water. How well the Airboat can traverse rice paddies and move through the tall marsh grass and reeds of the Delta is not known. During the wet season, when the paddies are flooded, there is sufficient water for the Airboat to function effectively on that type of surface, but a serious question relates to the ability of the Airboat to cross the numerous dikes (and ditches), depending on their width and depth. As noted, tests are currently being conducted by ACTIV to determine the Airboat's capabilities in the Delta environment.

The speed capabilities of the Marsh Screw in the types of conditions found in the Delta area are not known, although tests thus far indicate good performance under certain types of marsh conditions. Also, the Marsh Screw would undoubtedly function well and provide good speed over tidal mud. Its obstacle- and bank-crossing capabilities are more conjectural. Not enough is known about the performance of proposed vehicles based on Airoll and PATA concepts to permit specification of probable overland speeds, but it is likely that good speeds (similar to those of the M-113) would be possible over open paddy. Again, the steep banks of ditches or canals would be a major factor limiting overland speed.

The testing and operation of various GEM's under varied sets of conditions indicate that these vehicles could attain speeds of 50 to 60 miles per hour or more in rice paddy and marsh areas. Again, favorable conditions are assumed with respect to dike and bank heights. Narrow ditches could be crossed relatively easily, depending on the width of the ditch and the size of the GEM. In the longer term, the GEM will probably provide excellent mobility across paddy and marsh, even where dikes or banks are 3 to 4 feet high.

As previously discussed, the several types of obstacles prevalent in the Mekong Delta pose critical problems with respect to off-road mobility. To review briefly, the canal and river banks often make exits from a waterway very difficult, and the major and minor dikes enclosing rice paddies, together with ditches and elevated roadbeds, make overland movement rather tortuous. The most difficult trafficability problem confronted by the M-113 is that of exiting canals. Various techniques have been developed and employed to permit negotiation of this type of obstacle, but much time is always lost whenever special techniques are involved.

With perhaps one exception, it seems doubtful that any other of the alternative tracked amphibians considered in this study could overcome the canal bank problem more successfully than the M-113. The lighter M-116 (which will be described later), as adapted through a minor modification,[1] should be able to handle canal banks with equal or better facility than the M-113, but this capability would have to be demonstrated. The GEM, if it has sufficient cushion height, would be able to make effortless transitions from waterway to land. Remarkable improvements have been made in the obstacle-crossing capabilities of GEM's in recent years.

Paddy dikes and elevated roadbeds present a somewhat different type of obstacle than the stream bank because of the difference between the potential amount of traction that can be developed in the water or very soft mud on the bed or bank of a waterway and that which generally can be gained on land. Dikes and roadbeds present more serious problems for the smaller vehicles than for the larger ones. For the M-113, only larger obstacles of this type have caused severe problems (except when the dike or roadbed has been paralleled by a ditch). The comparatively large size and weight of the M-113 are generally major advantages in overcoming the obstacles posed by dikes or elevated roadbeds. However, the articulated-type tracked carrier, such as the XM-571 (described later), has a good obstacle-crossing capability despite its relatively small size and light weight. Whether it would be superior to the M-113 in crossing dikes and roadbeds is not known but, again, appropriate vehicle testing seems desirable. The XM-548, a logistic carrier using the M-113 chassis, and the M-116 (also described later) would probably function as effectively as the M-113 in overcoming such obstacles as dikes and roadbeds.

In addition to obstacle-crossing problems, vehicles confront the problem of traversing very weak soils. The relative capabilities of selected tracked vehicles and the Marsh Screw to traverse soft soils are shown in Table IX. In the table, 14 amphibians are ranked by computed vehicle cone index--a measure developed by the Waterway Experiment Station.[2]

---

1. As the M-116 is presently designed, the front of the hull extends slightly forward of the track and thus contacts a vertical obstacle before the track can engage it. This protrusion of the hull should be eliminated in future designs of the vehicle to improve its obstacle-crossing capability.
2. The vehicle cone index is a relative indication of the minimum soil strength (measured by the cone penetrometer) required for the vehicle to be mobile. It is not a precise measure, and small differences in indexes among particular vehicles are not significant.

Table IX

RELATIVE CAPABILITY OF SELECTED TRACKED VEHICLES TO TRAVERSE SOFT SOILS
(Assuming Vehicles Carry Rated Payloads)

Vehicle	Vehicle Cone Index[a]
Marsh Screw	11
Spryte	15
RN-15	15
RN-10	17
M-76	17
M-29	23
M-116	24
Marten	24
XM-571	25
Pack Rat	27
Super Marten	30
M-114	38
M-113	44
XM-548	47

a. Assuming level terrain.

Source: Stanford Research Institute.

The lowest vehicle cone index shown is seen to be that for the Marsh Screw. It is also apparent that the relatively lightweight, commercia-type vehicles identified as the Spryte, RN-15, and RN-10, with their very low ground pressures, are also able to traverse very weak soils, requiring a soil cone index strength of only 15-17 to be mobile. Each of these commercial-type amphibian vehicles, as developed for snow operations, could be highly mobile over the soils generally prevailing in the Delta area (disregarding obstacles). However, it is believed that they would be ill-suited to heavy-duty military use because of their lightweight structure.

At the bottom of the list in Table IX are the M-114, M-113, and XM-548, all three of which require nearly equivalent soil strengths to be mobile. The M-114 in use in Vietnam was found to be very poorly suited to conditions in the Delta, largely because the M-114 chassis was poorly configured for surmounting obstacles, and the vehicle is underpowered.[1] As indicated in the table, the M-114 should have slightly better weak-soil performance than the M-113, but its poor obstacle-crossing capabilities cause it to be inferior in terms of overall performance.

The Marsh Screw is of great interest as a vehicle concept offering the potential for good mobility over terrain presenting very adverse soil conditions. With test platforms, quite good capabilities have been indicated in certain types of situations approximating those found in the Delta area. However, the obstacle performance and the flexibility of this vehicle for operations away from the tidal-mud type of situation are yet to be fully appreciated. It would seem apparent that the Marsh Screw, in practical operational configurations designed to meet specific vehicle requirements, should be fully field tested by operational units in environments similar to those found in South Vietnam to enable due consideration of its potential for use by the ARVN.

Also included in Table IX are a number of smaller military vehicles, such as the M-76, M-29, and Marten. These vehicles have relatively good mobility under adverse soil conditions, but they are too small to be well suited for the potential requirement (personnel transport) for which off-road vehicles are being considered.

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1. In its testing and use, this vehicle was found to be quite inferior to the M-113 in mobility, and it has been withdrawn from Vietnam.

Of the various tracked vehicles considered, then, primary interest should be focused on the M-116 and the XM-571. Both are shown to be mobile on soils that are much too weak to be traversed by the M-113 (and the XM-548, the logistic carrier utilizing the M-113 chassis). Both the M-116 and the XM-571 are unarmored, both would be available as fully tested vehicles, both are amphibians, and both are of a size that appears to make them usable as off-road, unarmored personnel transports.

The M-116 has a nominal capacity of 3,000 pounds or 11 troops. Its total gross weight is 10,000 pounds. Significant numbers of this vehicle are currently available in the Army's vehicle inventory.

The XM-571 is an articulated-body, logistic-type carrier with a nominal capacity of 2,000 pounds or 10 troops. Its total gross weight is about 7,700 pounds. It is a fully tested vehicle that has in fact been produced in limited numbers--and could be produced in significant numbers with little delay.

Thus, it is concluded that these two vehicles should be given careful consideration for use in meeting the projected or potential requirement for off-road vehicles to be permanently deployed and continuously available at widely separated locales in the Delta area to meet immediate requirements for personnel transport.

In further consideration of the potential adoption of one or another of these unarmored vehicles and their introduction into South Vietnam in significant numbers, detailed comparisons should be made of their probable effectiveness in operational use and their probable effectiveness relative to that of the armored M-113 in similar use. Additionally, detailed comparisons of the probable costs of these alternative vehicles would be required as a basis for final selection.

Appendix A

PHOTOGRAPHS ILLUSTRATING VARIOUS CONDITIONS OF THE ENVIRONMENT
South Vietnam - Mekong Delta Area

Appendix A

PHOTOGRAPHS ILLUSTRATING VARIOUS CONDITIONS OF THE ENVIRONMENT
South Vietnam - Mekong Delta Area

Photo Number	Brief Description	Location	Month of Year
1	Mud Bank on Tidal Stream	10°30'N/106°37'E	September
2	Closeup of Tidal Mud	10°30'N/106°37'E	September
3	Canal Bank in Ca Mau	9°10'N/105°10'E	October
4	Canal Bank	9°45'N/105°30'E	October
5A	Barrier in Canal	10°30'N/106°E	October
5B	Barrier in Canal	Ca Mau Peninsula	October
6A	Vegetation in Canal	9°45'N/105°30'E	October
6B	Closeup of Vegetation in Canal	9°45'N/105°30'E	October
7	Paddy - Near Saigon	10°46'N/106°45'E	January
8	Paddy - NW of Go Cong	10°30'N/106°37'E	January
9	Low Field Dikes - NW of Go Cong	10°30'N/106°37'E	September
10	Paddy Dike with Foot Path - NW of Go Cong	10°30'N/106°37'E	September
11	Major Dike - NW of Go Cong	10°30'N/106°37'E	September
12	Paddy, Nipa Palm, and Tidal Streams - NW of Go Cong	10°32'N/106°37'E	September
13	Paddy with Settlement along Stream - W of My Tho	10°25'N/106°06'E	January

Photo Number	Brief Description	Location	Month of Year
14	Hamlet in Paddy Area - Near Can Tho	$10^{o}02'N/105^{o}46'E$	October
15	Paddy and Settlement along Major Canal - Between Sa Dec and Long Xuyen	$10^{o}20'N/105^{o}38'E$	January
16	Paddy along Lower Bassac River	$9^{o}40'N/106^{o}06'E$	May
·17	Open Paddy - Ca Mau Peninsula between Soc Trang and Ca Mau	$9^{o}25'N/105^{o}46'E$	September
18	Paddy and Coconut Plantation - SE of Vinh Long	$10^{o}10'N/106^{o}14'E$	December
19	Paddy and Plantation - Lower Ca Mau Peninsula	$8^{o}53'N/104^{o}55'E$	December
20	Plantation and Paddy - S of Rach Gia	$9^{o}53'N/105^{o}06'E$	September
21	Marsh - Plain of Reeds	$10^{o}38'N/106^{o}04'E$	March
22	Paddy and Marsh - Central Ca Mau Peninsula	$9^{o}19'N/105^{o}22'E$	June
23	Paddy and Marsh - Vegetation in Canals - NW of Soc Trang	$9^{o}42'N/105^{o}52'E$	May
24	Marsh - Central Ca Mau Peninsula	$9^{o}33'N/105^{o}23'E$	October
25	Marsh and Paddy - Central Ca Mau Peninsula	$9^{o}33'N/105^{o}23'E$	October
26	Mangrove SE of Saigon	$10^{o}33'N/106^{o}58'E$	January

Photo Number	Brief Description	Location	Month of Year
27	Mangrove - Inland along River in Lower Ca Mau Peninsula	$8^{o}47'N/105^{o}12'E$	September
28	Cajuput Swamp Forest - Ca Mau Peninsula	$9^{o}25'N/104^{o}58'E$	December
29	Brushwood Swamp SE of Ha Tien	$10^{o}17'N/104^{o}45'E$	October

Photo 1 Mud Bank on Tidal Stream
Location: $10^{\circ}30'N/106^{\circ}37'E$
September

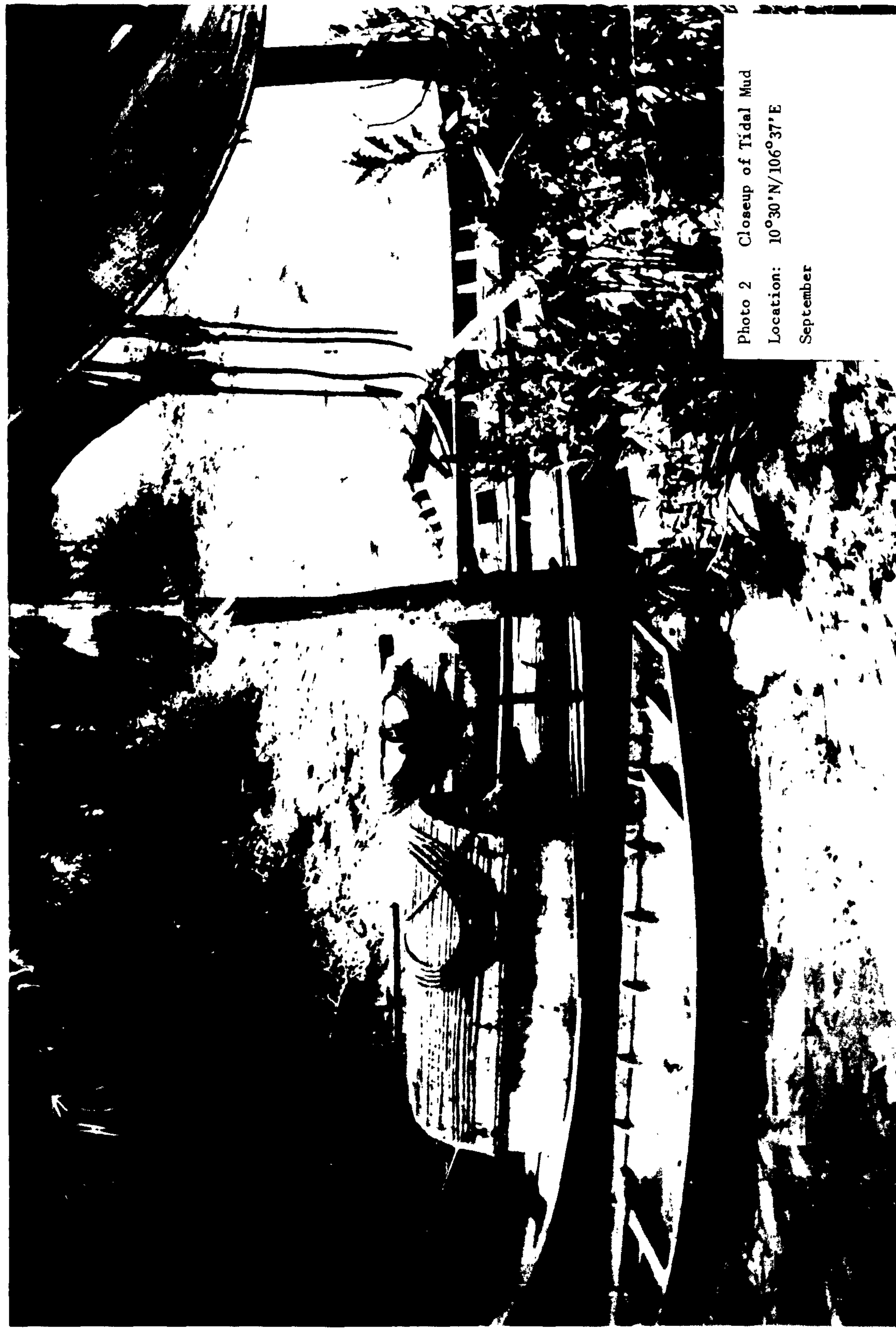

Photo 2 Closeup of Tidal Mud

Location: $10^{\circ}30'N/106^{\circ}37'E$

September

Photo 3 Canal Bank in Ca Mau
Location: 9°10'N/105°10'E
October

SECRET

Photo 4 Canal Bank
Location: 9°45'N/105°30'E
October

SECRET

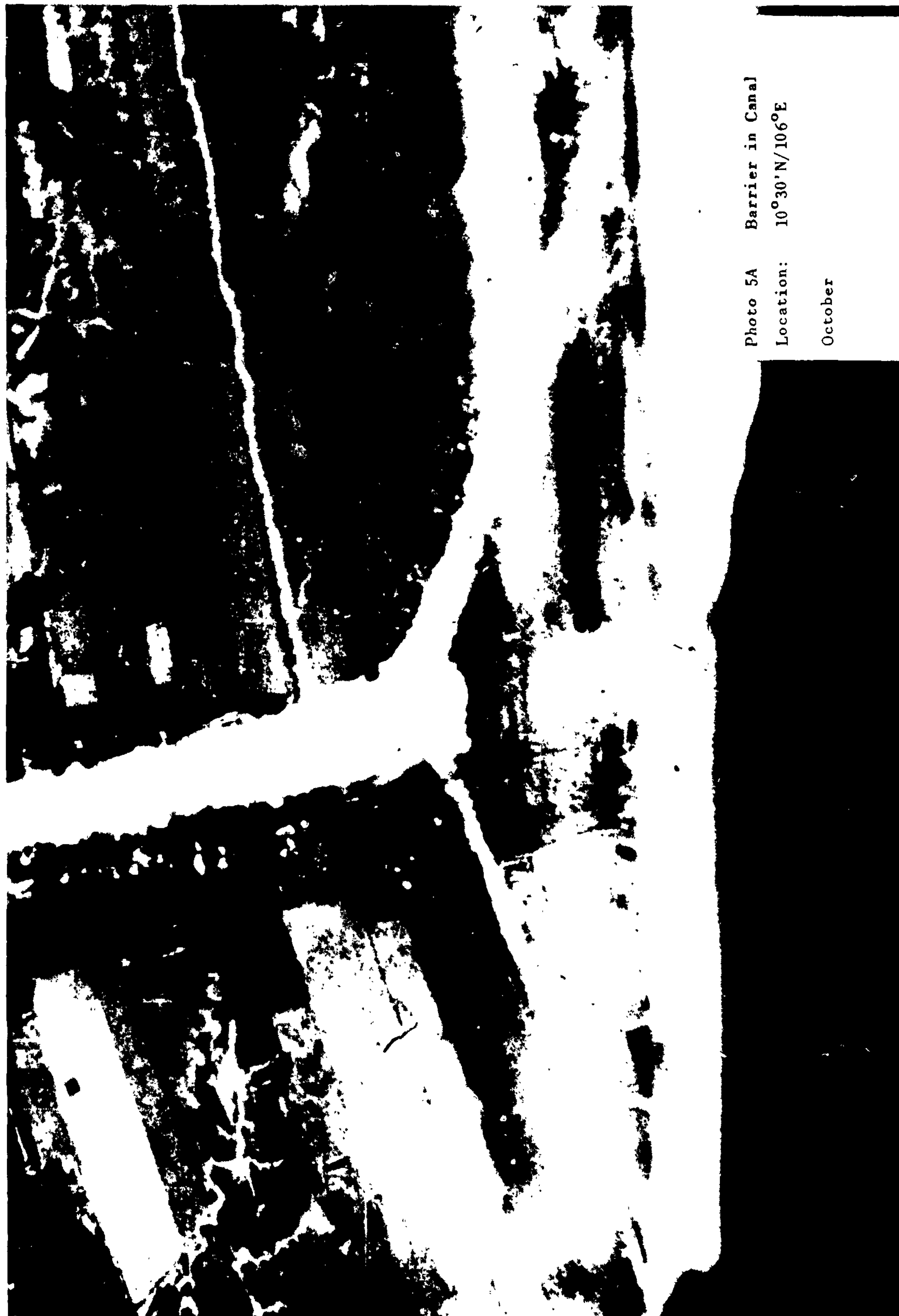

Photo 5A Barrier in Canal
Location: 10°30'N/106°E
October

SECRET

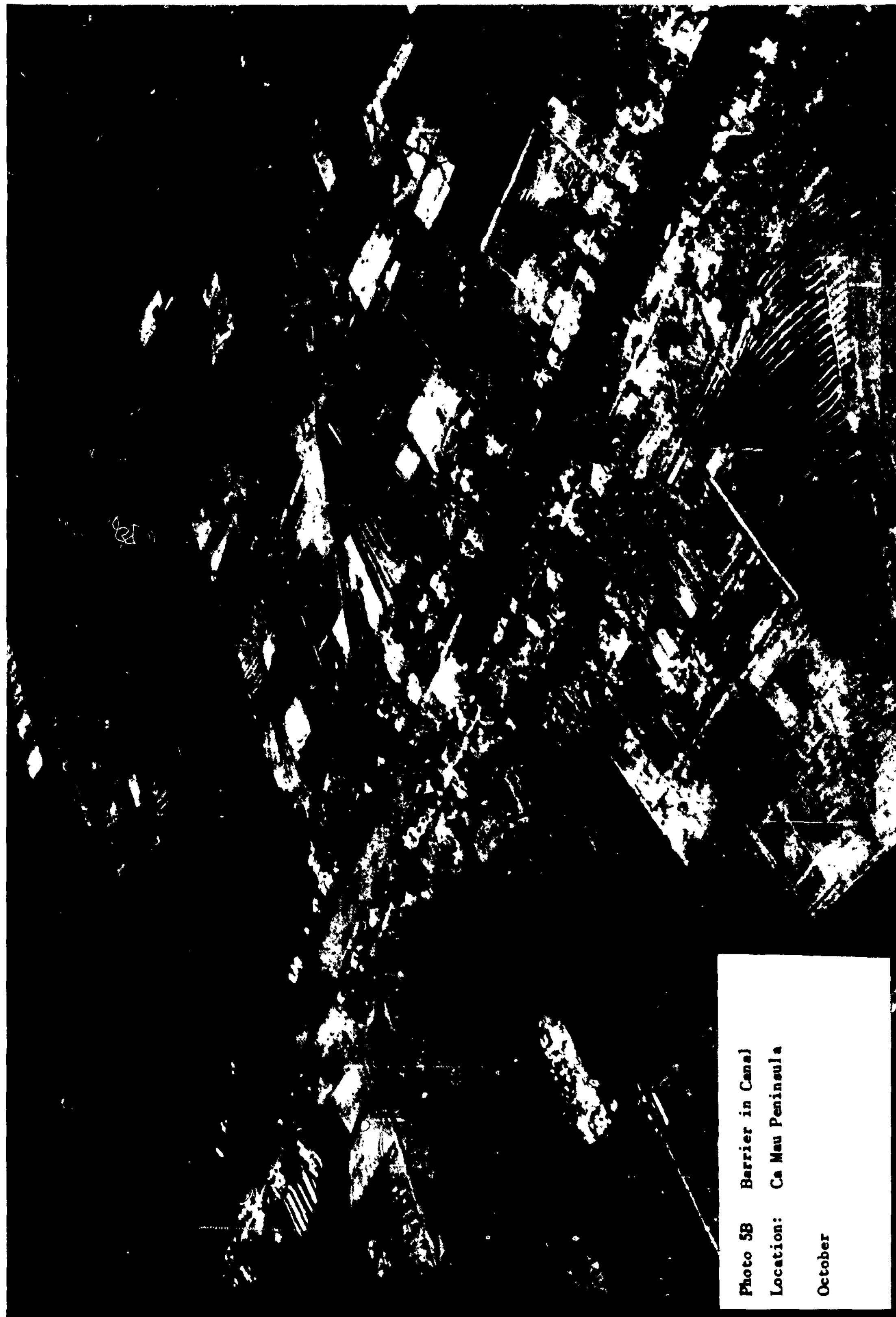

Photo 5B Barrier in Canal
Location: Ca Mau Peninsula
October

SECRET

Photo 6A Vegetation in Canal

Approximate
Location: 9°45'N/105°30'E

October

Photo 6B Closeup of Vegetation in Canal

Approximate Location: 9°45'N/105°30'E

October

SECRET


Photo 7 Paddy - Near Saigon
Location: 10°46'/106°45'E
January
N
0
meters
500


Photo 8 Paddy - NW of Go Cong
Location: 10°30'N/106°37'E
January
0
1000
2000
meters
N

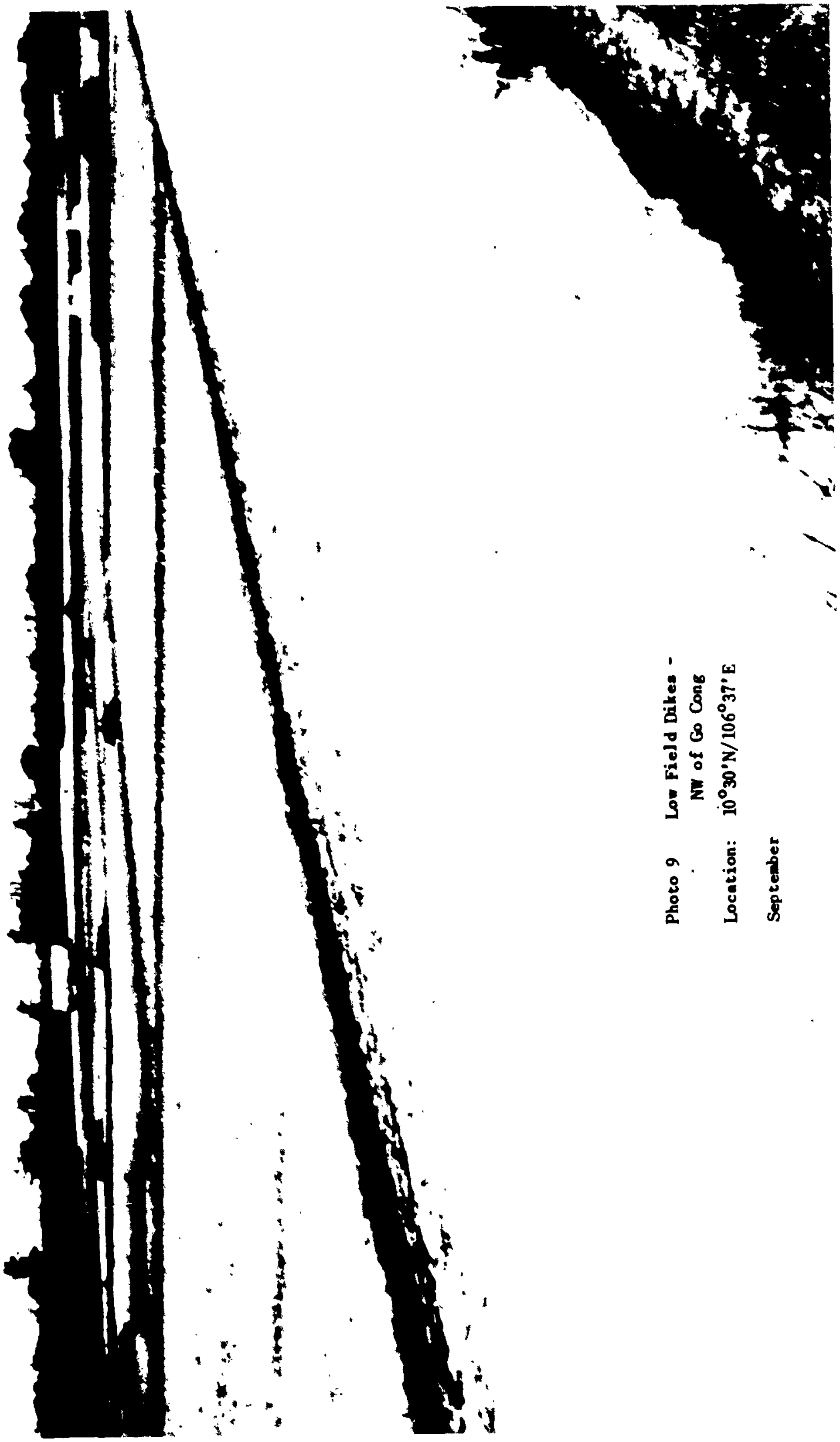

Photo 9 Low Field Dikes - NW of Go Cong

Location: $10^{\circ}30'N/106^{\circ}37'E$

September

Photo 10 Paddy Dike with Foot Path - NW of Go Cong

Location: 10°30'N/106°37'E

September

Photo 11 Major Dike - NW of Go Cong

Location: 10°30'N/106°37'E

September

Photo 12 Paddy, Nipa Palm and Tidal Streams - NW of Go Cong

Location: 10°32'N/106°37'E

September

Photo 13 Paddy with Settlement along Stream - W of My Tho

Location: 10°25'N/106°06'E

January

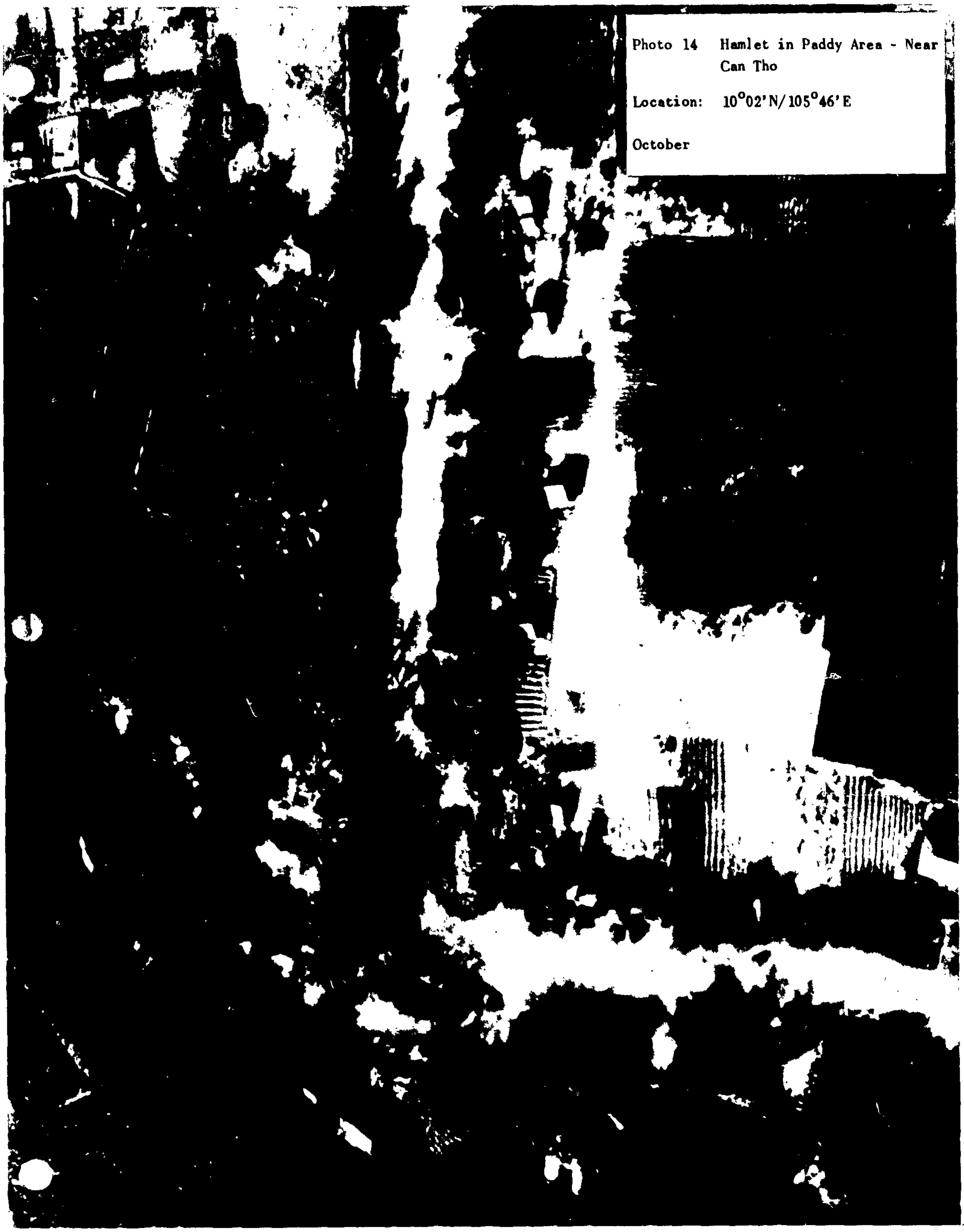

Photo 14 Hamlet in Paddy Area - Near Can Tho

Location: $10^{\circ}02'N/105^{\circ}46'E$

October

Photo 15 Paddy and Settlement along Major Canal - Between Sa Dec and Long Xuyen

Location: 10°20'N/105°38'E

January

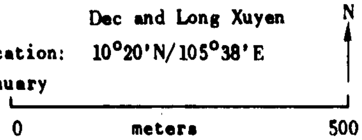

Photo 16 Paddy along Lower Bassac River

Location: 9°40'N/106°06'E

May

N

0 meters 500

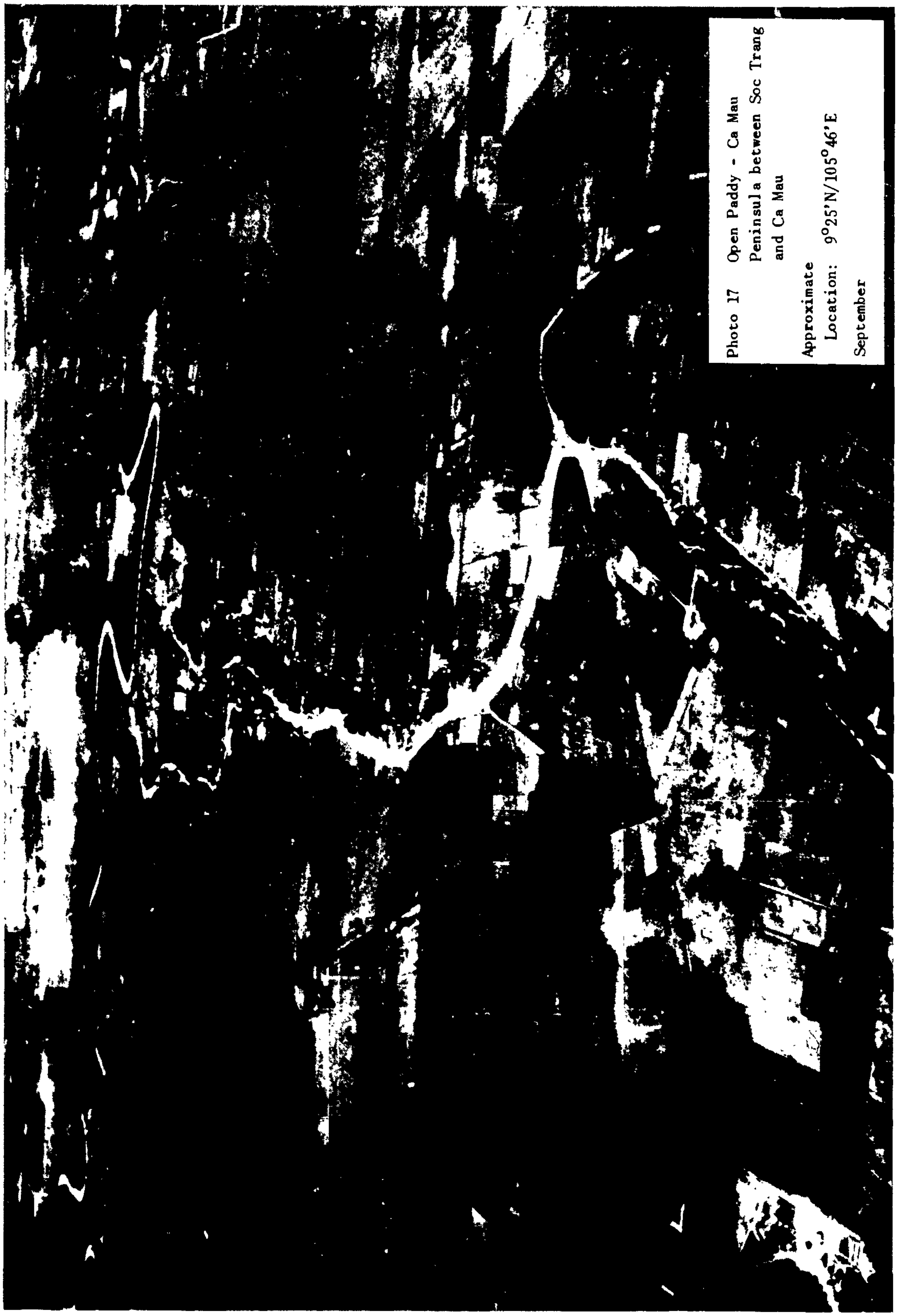

Photo 17 Open Paddy - Ca Mau Peninsula between Soc Trang and Ca Mau

Approximate Location: 9°25'N/105°46'E

September

SECRET

Photo 18 Paddy and Coconut Plantation - SE of Vinh Long

Location: 10°10'N/106°14'E

December

0 meters 400

N

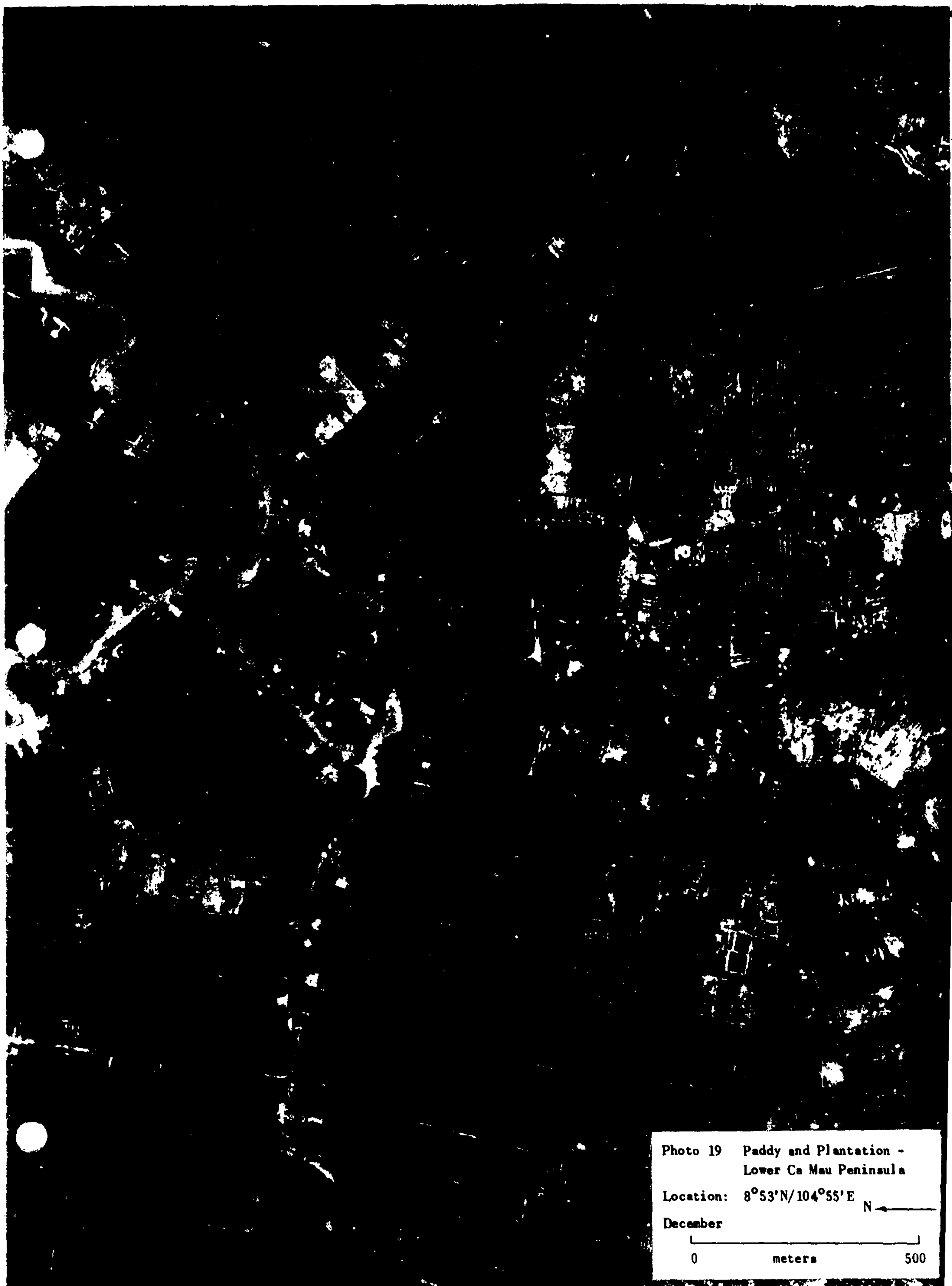

Photo 19 Paddy and Plantation - Lower Ca Mau Peninsula

Location: 8°53'N/104°55'E N ←

December

0 meters 500

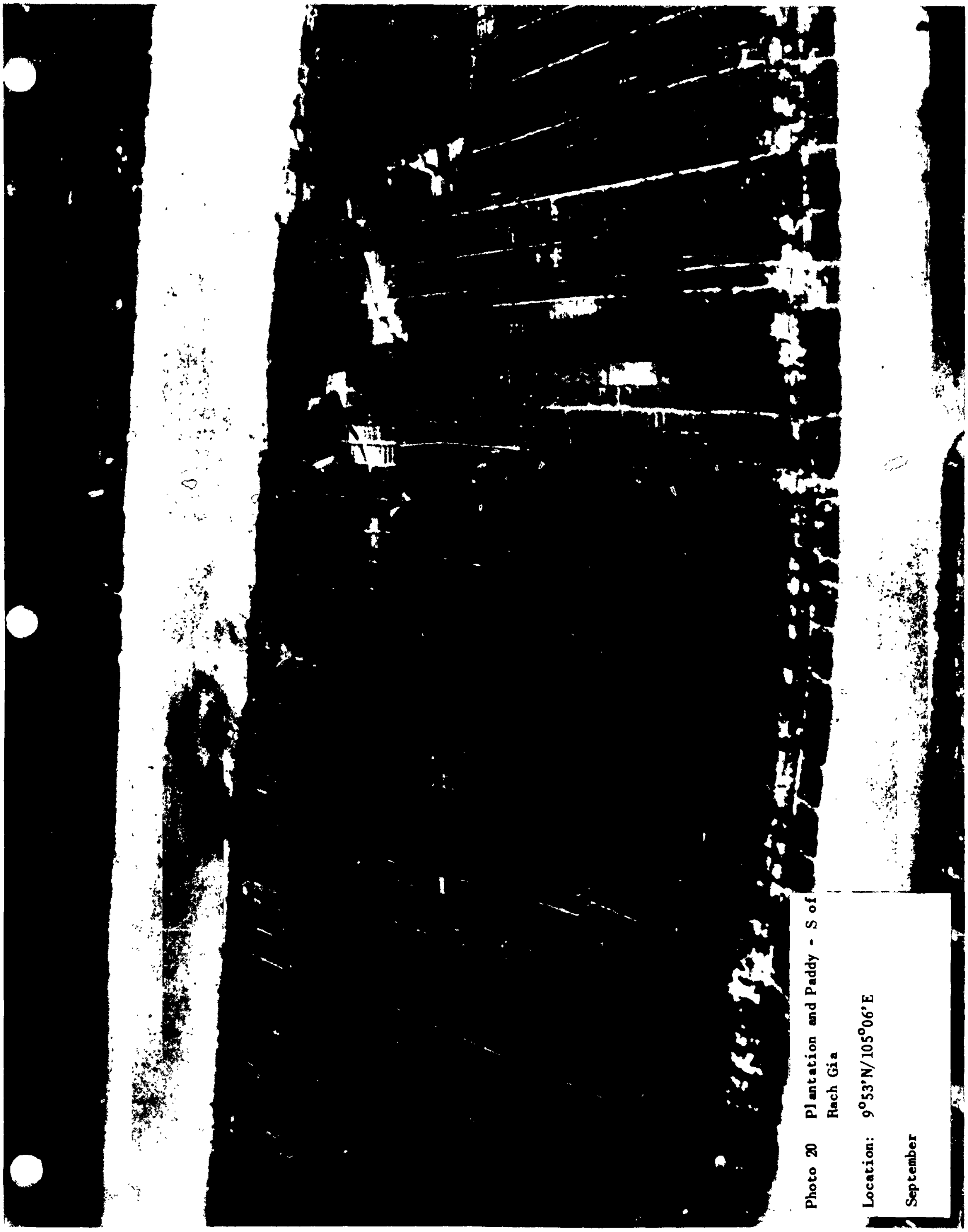

Photo 20 Plantation and Paddy - S of Rach Gia

Location: $9^{\circ}53'N/105^{\circ}06'E$

September

Photo 21 Marsh - Plain of Reeds

Location: 10°38'N/106°04'E

March

N

0 meters 400


Photo 22 Paddy & Marsh - Central Ca Mau Peninsula
Location: 9°19'N/105°22'E
N
June
0 meters 400

SECRET

Photo 23 Paddy and Marsh - Vegetation in Canals - NW of Soc Trang

Location: 9°42'N/105°52'E

May

N

0 meters 500

SECRET

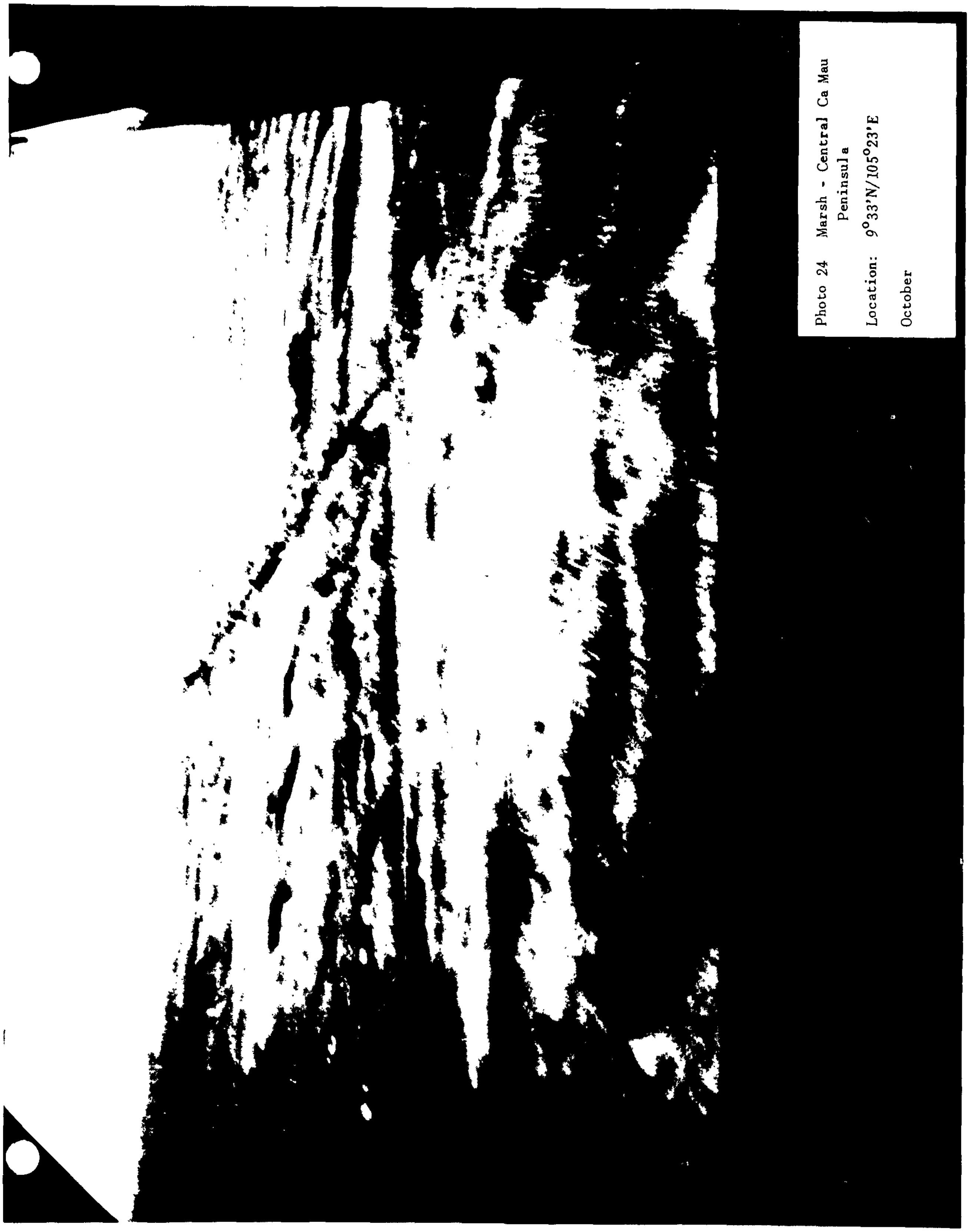

Photo 24 Marsh - Central Ca Mau Peninsula

Location: $9^{\circ}33'N/105^{\circ}23'E$

October

SECRET

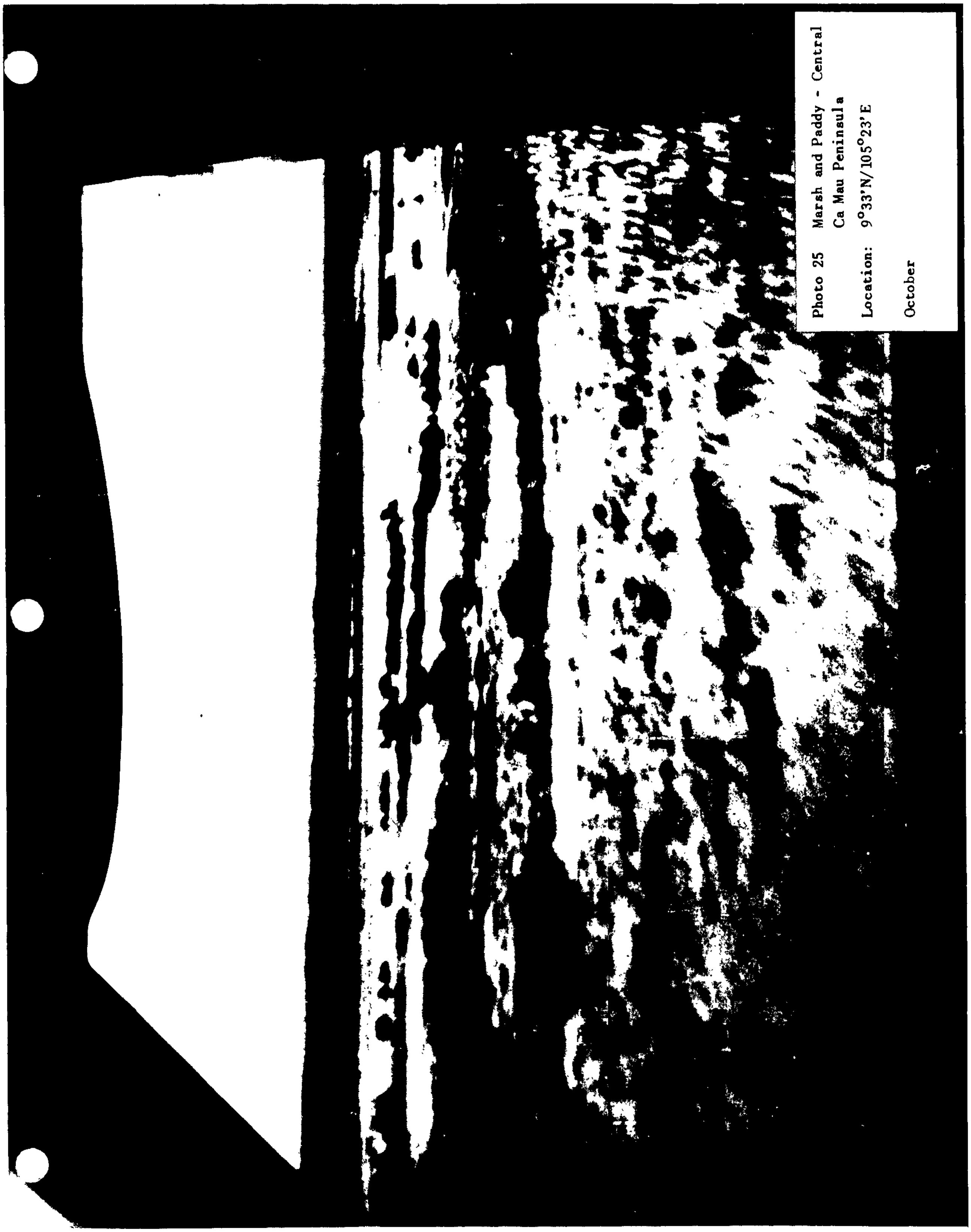

Photo 25 Marsh and Paddy - Central Ca Mau Peninsula

Location: $9^{\circ}33'$N/$105^{\circ}23'$E

October

Photo 26 Mangrove SE of Saigon

Location: 10°33'N/106°58'E

January N ←

0 meters 500

SECRET

Photo 27 Mangrove - Inland along River in Lower Ca Mau Peninsula

Location: 8°47'N/105°12'E

September

N

0 meters 500

SECRET

Photo 28 Cajuput Swamp Forest - Ca Mau Peninsula

Location: 9°25'N/104°58'E

December

N ←

0 meters 500

Photo 29 Brushwood Swamp
SE of Ha Tien

Location: 10°17'N/104°45'E

October

0 meters 500

N

Appendix B

BASIC CHARACTERISTICS OF WATER CRAFT PRESENTLY EMPLOYED BY ARMED FORCES IN THE MEKONG DELTA AREA

Appendix B

BASIC CHARACTERISTICS OF WATER CRAFT PRESENTLY EMPLOYED BY ARMED FORCES IN THE MEKONG DELTA AREA

Water Craft	Length (feet)	Beam (feet)	Draft Loaded (feet)	Displacement Loaded (pounds)	Payload (pounds)	Troop Capacity (number)	Maximum Speed (knots)
LCVP	36	10.8	3.3	26,600	8,000[a]	33-36	10.4[b]
STCAN	37.7	9.9	2.5	26,000	n.a.	n.a.	10.0[b]
LCM-6	56	14	4	124,000	68,000[a]	80-120	10.9[b]
LCU (1466 Class)	119	34	6	720,000	360,000[a]	700	8.0[b]
Dong Nai Boat							
Early model	14.3	6.9	1-2[c]	--	2,100[d]	14	17
Modified	17.5	6	1-2[c]	--	2,100[d]	14	17
Sampan (smallest)	12-15	3-4	1	--	500	4-5	Minimal

Note: There are many powered sampans of local construction. The sampans vary considerably in size and configuration. Powered with long-shaft motors, they may attain speeds up to 15 knots. They have a very shallow draft.

n.a. means not available.

a. These payloads are representative of unarmored craft. With armor plate, these payloads are reduced somewhat.
b. These speeds are representative of unarmored craft. With armor plate, these speeds are reduced 3 to 4 knots.
c. Operated with paddle, 1 foot; operated with outboard motor, 2 feet.
d. Weight of 14 troops, assuming average troop weight of 150 pounds.

Source: Stanford Research Institute.

Appendix C

BASIC CHARACTERISTICS OF ALTERNATIVE TYPES AND SIZES OF CRAFT POTENTIALLY SUITABLE FOR INLAND WATERWAY OPERATION

Appendix C

BASIC CHARACTERISTICS OF ALTERNATIVE TYPES AND SIZES OF CRAFT POTENTIALLY SUITABLE FOR INLAND WATERWAY OPERATION

Water Craft	Length (feet)	Beam (feet)	Draft Loaded (feet)	Displacement Loaded (pounds)	Payload (pounds)	Troop Capacity (number)	Maximum Speed (knots)
Airboat (14)	14	5.9	1	n.a.	850	3	48
Boston Whaler	13.3	5.3	1[a]	1,450	1,200	n.a.	19[b]
Boston Whaler	16.7	6.1	1[a]	2,900	2,400	9	33[b]
Airboat (17)	17.0	7.2	1	n.a.	2,000	6-8	52
MRDC-4 (Klong Boat)	21.3	3.8	1[a]	3,064	2,094	4-6	27[b]
Patrol Cruiser (hydrokeel)	32.0	11.8	2.2	12,000[c]	n.a.	n.a.	48
River Patrol Craft	35.9	10.8	3.5	29,000	3,000	12-18	15
LCVP(K)	36.0	11.0	3.3	26,000	3,000	n.a.	30
LCVP(H)	36.0	n.a.	n.a.	24,000	n.a.	n.a.	35+
Picket	36.5	11.0	3.3	17,700	500	n.a.	25
Rescue 1	40	12	2.5	26,920[d]	n.a.	n.a.	21
Utility	40	12	2.9	27,715	11,000	71	11
Hydrofoil	42	n.a.	n.a.	28,000	7,000	25	50
Rescue 2	46	14	3	32,000[d]	n.a.	n.a.	33
LCSR(K)	51	14	n.a.	50,000	n.a.	n.a.	50
Polyhedral	53	16	4	40,851	12,851	30	35
Monitor 990 (French)	64	18	3.5	134,400	n.a.	n.a.	10.5
LCM-8	74	21	5.2	254,000	120,000	200	12
PT	79	20	4.5	100,000	10,000	n.a.	42

Appendix D

BASIC CHARACTERISTICS OF VEHICLES PRESENTLY EMPLOYED BY ARMED FORCES IN THE MEKONG DELTA AREA

Appendix D

BASIC CHARACTERISTICS OF VEHICLES PRESENTLY EMPLOYED BY ARMED FORCES IN THE MEKONG DELTA AREA

Vehicle	Length Overall (inches)	Width Overall (inches)	Ground Pressure (psi)	Gross Vehicle Weight (pounds)	Payload (pounds)	Vehicle Cone Index	Water Speed (mph)
Amphibians							
M-113	191	106	7.3	23,860	3,800	44	3.5
Non-Amphibians							
M-151	131	62	n.a.	3,073	500	56	None
M-37	191	74	n.a.	7,417	1,500	66	None
M-35	262	96	n.a.	17,465	5,000	59	None
M-41	310	96	n.a.	29,469	10,000	63	None

Note: There are also some old, armored, wheeled vehicles obtained from Malaya and a few old half-tracked vehicles, all of which are non-amphibious.

n.a. means not available.

Source: Stanford Research Institute.

Appendix E

BASIC CHARACTERISTICS OF ALTERNATIVE TYPES AND SIZES
OF AMPHIBIAN VEHICLES

Appendix E

BASIC CHARACTERISTICS OF ALTERNATIVE TYPES AND SIZES OF AMPHIBIAN VEHICLES

Vehicle	Length Overall (inches)	Width Overall (inches)	Ground Pressure (psi)	Gross Vehicle Weight (pounds)	Payload (pounds)	Vehicle Cone Index	Water Speed (mph)	Type
Pack Rat	118	68	n.a.	4,000	1,000	27	4.0	Conv.
Marten	120	66	n.a.	2,450	1,000	24	n.a.	Conv.
RN-10	125	66	1.0	3,300	1,000	17	n.a.	Conv.
Airoll .75	127	90	n.a.	7,300	1,500	*	n.a.	Airoll
T-114C	139	102	n.a.	12,000	6,000	*	n.a.	Conv.
Super Marten	144	68	n.a.	5,900	3,000	30	n.a.	Conv.
Airoll 4 (T)	154	90	n.a.	7,300	1,500	*	n.a.	Airoll
RN-15	155	71	1.0	4,750	1,500	15	n.a.	Conv.
T-107	156	72	n.a.	7,400	1,000	35	n.a.	Conv.
Spryte 1301	157	77	0.8	3,850	1,000	15	4.2	Conv.
RAT CL-70	157	48	n.a.	2,500	1,000	*	n.a.	Artic.
M-114	168	94	4.5	15,100	2,000	38	n.a.	Conv.
Marsh Screw	168	98	0.9	3,735	1,000	11	7.5-15.0	Screw
C & R	181	95	6.5	18,500	1,000	44	4.1	Conv.
M-116	182	82	2.4	10,600	3,000	24	4	Conv.
T-122C	188	106	n.a.	24,000	10,100	*	n.a.	Conv.
T-46E1	188	98	n.a.	12,000	3,000	*	n.a.	Conv.
M-29	192	67	2.0	6,000	1,000	23	4	Conv.
LVA-XI	194	96	5.0	6,150	1,200	*	6.4	Airoll
M-76	199	98	2.4	12,000	3,000	17	4.5	Conv.
LVA-X1(Q)	200	96	n.a.	6,250	1,200	*	n.a.	Airoll
Airoll 5	204	100	n.a.	20,000	10,000	*	15.0	Airoll
PATA	206	116	1.2	5,100	2,400	*	n.a.	Airoll

Appendix E (concluded)

Vehicle	Length Overall (inches)	Width Overall (inches)	Ground Pressure (psi)	Gross Vehicle Weight (pounds)	Payload (pounds)	Vehicle Cone Index	Water Speed (mph)	Type
Dynaroll	211	108	n.a.	9,000	3,000	*	n.a.	Airoll
Airoll 8(T)	216	120	n.a.	16,300	5,000	*	n.a.	Airoll
M-59	221	124	n.a.	42,000	3,000	*	n.a.	Conv.
XM-548	227	106	7.4	24,450	10,000	47	3.6	Conv.
XM-546E1	229	106	6.6	26,000	10,000	45	3.6	Conv.
XM-571	234	64	2.1	7,700	2,000	25	2.1	Artic.
Airoll 8	253	120	n.a.	30,135	16,000	*	n.a.	Airoll
LVTP-6	259	129	7.9	50,600	8,000	64	5.5	LVT
MT-2	269	124	n.a.	25,450	10,000	*	n.a.	Conv.
MT-4	269	124	n.a.	25,000	10,000	*	n.a.	Conv.
MT-1	280	120	n.a.	27,000	10,000	*	n.a.	Conv.
Airoll 4(TT)	295	90	n.a.	16,300	8,000	*	n.a.	Airoll
LVTPX-12	312	126	n.a.	45,000	10,000	*	n.a.	LVT
LVTP-5	356	140	9.2	81,780	12,000	*	6.8	LVT
MT-6	376	119	n.a.	25,480	10,000	*	n.a.	Artic.
MT-5	378	84	n.a.	25,000	6,000	*	n.a.	Artic.
Airoll 8(TT)	449	120	n.a.	32,300	16,000	*	n.a.	Airoll
LCA	681	252	10.1	136,400	60,000	*	12.0	LVT

n.a. means not available.

* Insufficient basis for calculation.

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13. ABSTRACT
This study has been concerned with the identification of techniques and equipments that could be adopted and made available in the immediate time period to produce significant improvements in the mobility of military forces in the Mekong Delta area of South Vietnam. The limitations on mobility imposed by the physical environment in the Delta area have been analyzed in detail. The types of activities in which improved mobility is probably essential to effective Vietnamese counterinsurgent operations have been identified. Alternative types of small craft and off-road vehicle designs have been assessed as to their potential suitability in providing improved mobility in specific types of situations and environments in the immediate time period.

14. Key words: Project AGILE - Counterinsurgent Operations, Riverine Operations, Requirements for Movement; South Vietnam - Military Geography, Off-road Mobility, Environment, Tidal Conditions, Surface Conditions, Waterways, Vehicle Performance; Counterinsurgency; Riverine Operations; Off-road Mobility.

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